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SUPPLEMENT, NO. 3.

MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

VOL. 50 NO. 5.
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MAY, 1922.

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AN AEROLOGICAL SURVEY OF THE UNITED STATES.[1]

PART I. RESULTS OF OBSERVATIONS BY MEANS OF KITES.

By WILLIS RAY GREGG, Meteorologist.

[Author's Abstract.]

Aerological investigations by means of kites, pilot and sounding balloons have been carried on by the Weather Bureau for several years. In addition, there is available a large amount of similar data secured by the Blue Hill Observatory and by the meteorological services of the War and Navy Departments. Although the material at hand is not sufficient for a *final* analysis of the results, it nevertheless seems appropriate to summarize and publish such results as we have as soon as possible after they are obtained in order that they may be available for the information and use of those most interested in them. Subsequent revisions, although of some importance in that they furnish results of greater precision, will hardly affect the practical value of these data which are so much needed at the present time, particularly in connection with aviation and ordnance. To meet this need there is being prepared a series of summaries under the general heading "An Aerological Survey of the United States." The first part, just issued and the subject of this abstract, gives the results of observations by means of kites. It contains, in addition to the discussion, numerous figures and tables from which can be obtained detailed information as to the characteristics of the free air over the United States east of the Rocky Mountains. Much of this detailed information will necessarily be of interest only to those to whom it is vital, principally aviators, and the edition is therefore a limited one. To many others a briefer, more general review, giving the main results, will be sufficient. The present abstract or review endeavors to supply this more general need.

For the most part the results are based upon observations with kites at the six stations established by the Weather Bureau during the period 1915 to 1918, but in Figures 2 to 4 mean values have been used as determined from observations at Mount Weather, Va., and Blue Hill Observatory, Mass., in order to give as complete a picture as possible of free-air conditions over the eastern and central portions of the United States. The stations, their geographic coordinates, and the periods of observation are given in Table 1.

Station.	Altitude, m. s. l.	Latitude, N.	Longitude, W.	Period of observation (inclusive).	
				From—	To—
	m.	° ′	° ′		
Broken Arrow, Okla.	233	36 02	95 49	Aug. 1918	Dec., 1920
Drexel, Nebr.	396	41 20	96 16	Oct., 1915	Do.
Ellendale, N. Dak.	444	45 59	98 34	Jan., 1918	Do.
Groesbeck, Tex.	141	31 30	96 28	Oct., 1918	Do.
Leesburg, Ga.	85	31 47	84 14	Mar., 1919	June, 1920
Royal Center, Ind.	225	40 53	86 29	July 1918	Dec. 1920
Blue Hill, Mass.	195	42 13	71 07	1896	1903
Mount Weather, Va.	526	39 04	77 53	July, 1907	June, 1912

[1] MONTHLY WEATHER REVIEW SUPPLEMENT, No. 20, pp. 78, figs. 25. Washington, D. C., 1922.

In the original paper a series of tables gives for the stations listed in Table 1, except Blue Hill and Mount Weather, the mean monthly, seasonal, and annual barometric and vapor pressures in mb.; temperatures in degrees centigrade; relative humidities in percentages; densities in kg. per cu. m. and in percentages of standard (standard = 1.293 kg. per cu. m.); and wind resultants in degrees and m. p. s. Mean seasonal values of temperature, relative humidity, and vapor pressure are shown also in three figures. In this abstract the tables and two of the figures are omitted. Figure 1 shows the mean seasonal free-air temperatures at the six stations. Conspicuous features brought out by these data are the decided permanent inversion of temperature in the lower levels at northwestern stations during the winter; the large latitudinal difference in annual temperature range, both surface and free-air; the small annual range in relative humidity at the northern stations, but the large range, with highest in summer, at the southern stations; and the substantial agreement in the annual range of vapor pressure at all stations, this range of course becoming very small in the higher levels.

Some of the original data are presented in somewhat different form in Figures 2 to 4, inclusive. Each figure consists of 12 small outline maps of the United States, representing different levels and showing for those levels the mean summer and winter values of pressure, temperature, and resultant wind. In order to make these maps as complete as possible for the eastern and central portions of the country, there have been included the mean values at Blue Hill, Mass., and Mount Weather, Va., each based upon a long series of observations made with kites several years ago. The values for Blue Hill have been taken from Clayton's study of the diurnal and annual periods of temperature, humidity, etc.[2] In that publication only the mean temperatures and relative humidities are given, but with these data it has been possible to compute the mean pressures (barometric and vapor) and the mean densities. In order to test the accuracy of these computed values, similar computations were made for all other stations and then compared with the means as determined from the individual observations themselves. In all cases the agreement was strikingly close. The values for Mount Weather have been taken from a previous paper.[3] Neither at Blue Hill nor at Mount Weather were the observations of wind summarized in such form as to make possible the determination of wind resultants. The wind charts are therefore not as complete as are those for the other elements.

[2] Clayton, H. H. *Annals of the Astronomical Observatory of Harvard College.* Vol. LVIII, Pt. I, p. 59. 1904.

[3] Mean values of free-air barometric and vapor pressures, temperatures, and densities over the United States. By W. R. Gregg. MONTHLY WEATHER REVIEW, January, 1918. 46:11-20.

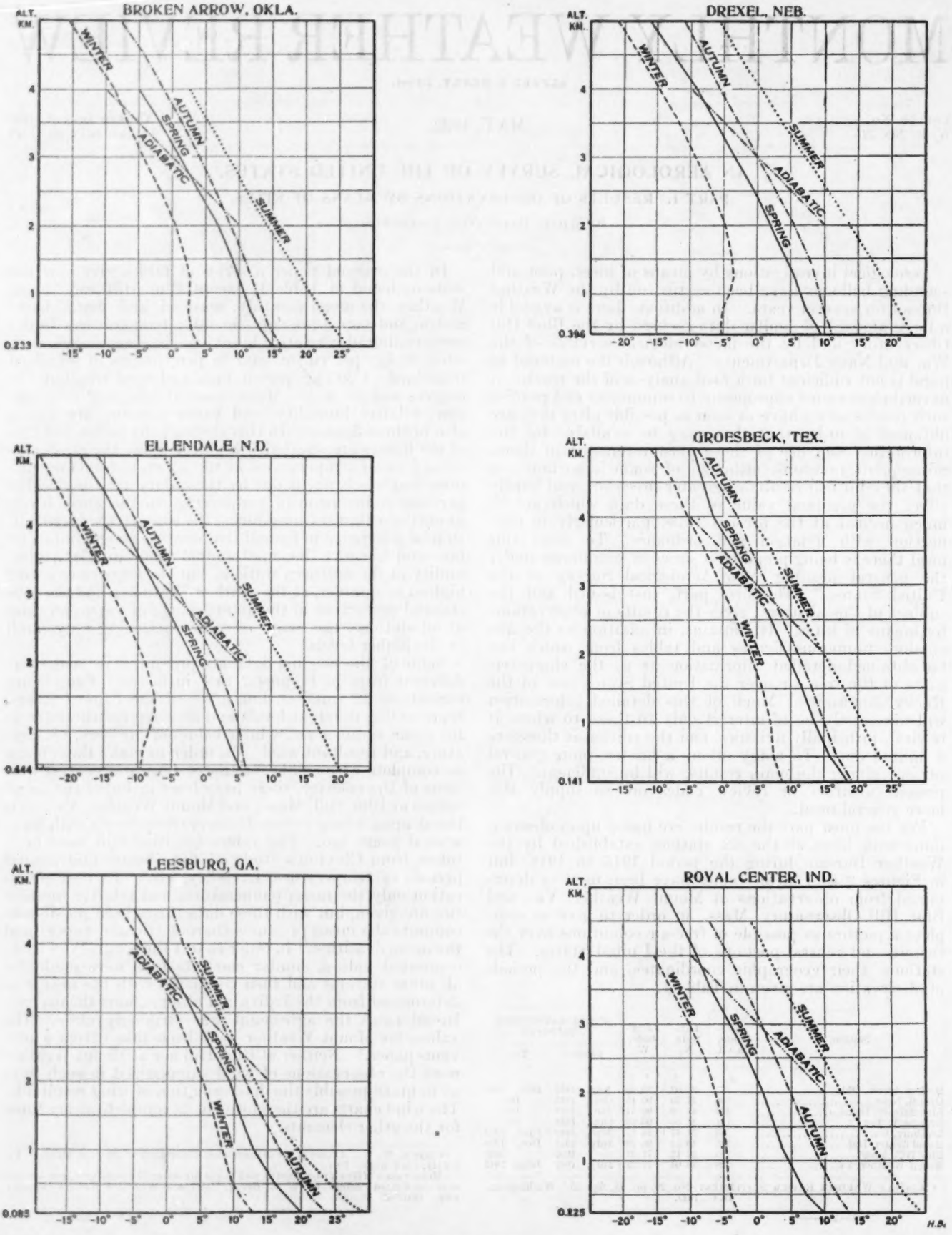


FIG. 1.—Mean seasonal free-air temperatures, °C.

The figures are published in such a way that the contrast between summer and winter conditions may be seen at a glance. Thus, the summer and winter mean barometric pressures, respectively, appear side by side on the same page, in Figure 2. The same arrangement holds for the other elements. All contain, in addition to the iso-lines, the locations of the stations and the mean values for those stations.

An examination of these charts, and others not published here, brings out the following points:

1. The large difference between summer and winter conditions at all levels and at all latitudes.

2. The substantial parallelism in the lines of equal pressure and temperature at all levels. This is to be expected since, as is well known, the pressure at any given level is largely a function of the temperature of the air beneath that level.

3. The slight southward trend of isobars and isotherms in the upper levels from the interior to the eastern portions of the country. In this connection it is interesting to note that in winter this trend of the isotherms in the upper levels is the opposite of that at and near the surface. In other words, on the same parallels of latitude, except in the Southern States, the air from the surface to about 1 kilometer above it is warmer in the East than in the Middle West but considerably colder at greater altitudes. As is well known, cyclonic storms in this country, no matter where they originate, pass out as a rule across or near the New England States. These storms are most frequent and intense in winter and, because of the almost continuous procession of them through the Northeast, produce a resultant low pressure in that section. To some extent, then, the lower free-air temperatures in the East are due to dynamic cooling, but the differences are too great to be accounted for wholly in this way. They are probably due in large part to the following circumstance: Many of the cyclones referred to originate in the South or Southwest, and these usually intensify as they travel, becoming storms of marked vigor by the time they have passed into the Atlantic. During the time that they are near or off the coast the pressure gradient westward is steep, resulting in strong northerly and northwesterly winds which bring in large masses of very cold air. Clayton, as the result of his studies of Blue Hill data, states [4] that "with increase of height the temperature falls more rapidly in the rear of the cyclone than it increases in front." The frequency with which this condition occurs is in all likelihood largely responsible for the lower mean free-air temperatures in the Northeast than at the same latitudes in the Middle West. To a less extent this is true also for summer, when it applies to all levels, even the surface. In the winter, however, as already stated, the reverse is found at and near the surface, i. e., the Middle West is much colder than the East, a condition which is readily explained by the frequent occurrence of anticyclonic weather, with its clear skies and intense radiation. This is distinctly a characteristic feature of continental climate, and that it is purely a surface phenomenon is evident from the pronounced temperature inversions that are almost invariably found and whose magnitudes are such as to produce a resultant inversion even in the mean values for the entire season, as is well shown in Figure 1. Occasionally a rapid succession of HIGHS passing over a given place tends to a gradual thickening of the stratum of cold air and the consequent disappearance of the temperature inversion. Notable instances occurred during the cold winter of 1917–18. Such cases are, however, exceptions to the rule.[5]

4. The higher relative humidity in the South than in the North during summer and the opposite gradient during winter, owing in all probability to the more pronounced convectional activity in the South during summer and to the greater storminess in the North during winter.

5. The close agreement in the summer and winter latitudinal range of vapor pressure at all altitudes. This is largely explained by the circumstance that, although the latitudinal temperature range is much greater in winter than in summer, yet, on the other hand, the change in vapor pressure is much less for a given change in temperature when the latter is in general low than when it is high, the relation between temperature and vapor pressure being logarithmic, not linear. Another contributing cause of the similarity in the latitudinal range of vapor pressure during summer and winter is the fact that the relative humidity diminishes northward during summer, thus adding to the relatively small effect of the moderate temperature range, but diminishes *southward* during winter thus acting against the relatively large effect of the steep temperature gradient in that season.

6. The small latitudinal density gradient in the higher levels, owing to the counterbalancing effects of pressure and temperature, i. e., density varies directly with pressure; inversely with temperature. It is also worthy of note that the annual range diminishes markedly with altitude. Observations at greater heights would undoubtedly show practically the same values in all parts of the country and throughout the year at about the 8-kilometer level.[6] The question of standard density, or a "standard atmosphere," is receiving considerable attention at present in connection with aviation and with the firing of projectiles. This subject has been discussed at some length in the original paper and also in a Special Report, No. 147, issued by the National Advisory Committee for Aeronautics. It is thought unnecessary, therefore, to make further reference to it here.

7. The small latitudinal difference in resultant wind speeds, due to the fact that these vary directly with the pressure gradient, but *inversely* with the sine of the latitude. An exception is to be noted in the case of the southern stations in summer, but it should be borne in mind that that region is not during the summer under the control of the prevailing westerlies, but rather that of the "horse latitudes." Winds are light and variable, and a longer record is necessary for the determination of true resultant values. With this exception the arrows in the charts show a very close relation to the mean pressure gradients. In general at all altitudes there is a southerly component in summer and a northerly in winter. A further examination of these charts, together with a study of Bowie and Weightman's work on the movement of cyclones,[7] brings out a fact of considerable significance. From the data given in Table 2, page 8, of that work it is possible to compute the average summer and winter rates of movement of all storms. The resulting values are, respectively, 9.3 and 13.4. Reference to Figure 4 shows that these rates of movement are in striking agreement with the resultant wind speeds at 3 to 4 kilometers,

[4] The distribution of the meteorological elements around cyclones and anticyclones up to 3 kilometers at Blue Hill. By H. H. Clayton. *Annals of the Astronomical Observatory of Harvard College.* Vol. LXVIII, Pt. I. 1909.

[5] For further discussion of this subject the reader is referred to: Some observations on temperatures and winds at moderate elevations above the ground. By V. E. Jakl. MONTHLY WEATHER REVIEW, June, 1919, 47:367–373. Of particular interest are Figures 1, 3, and 4 and accompanying text.

[6] See: Level of constant air density. By W. J. Humphreys. MONTHLY WEATHER REVIEW, May, 1921, 49:280–281.

[7] Types of storms of the United States and their average movements. By E. H. Bowie and R. H. Weightman. MONTHLY WEATHER REVIEW SUPPLEMENT No. 1, 1914.

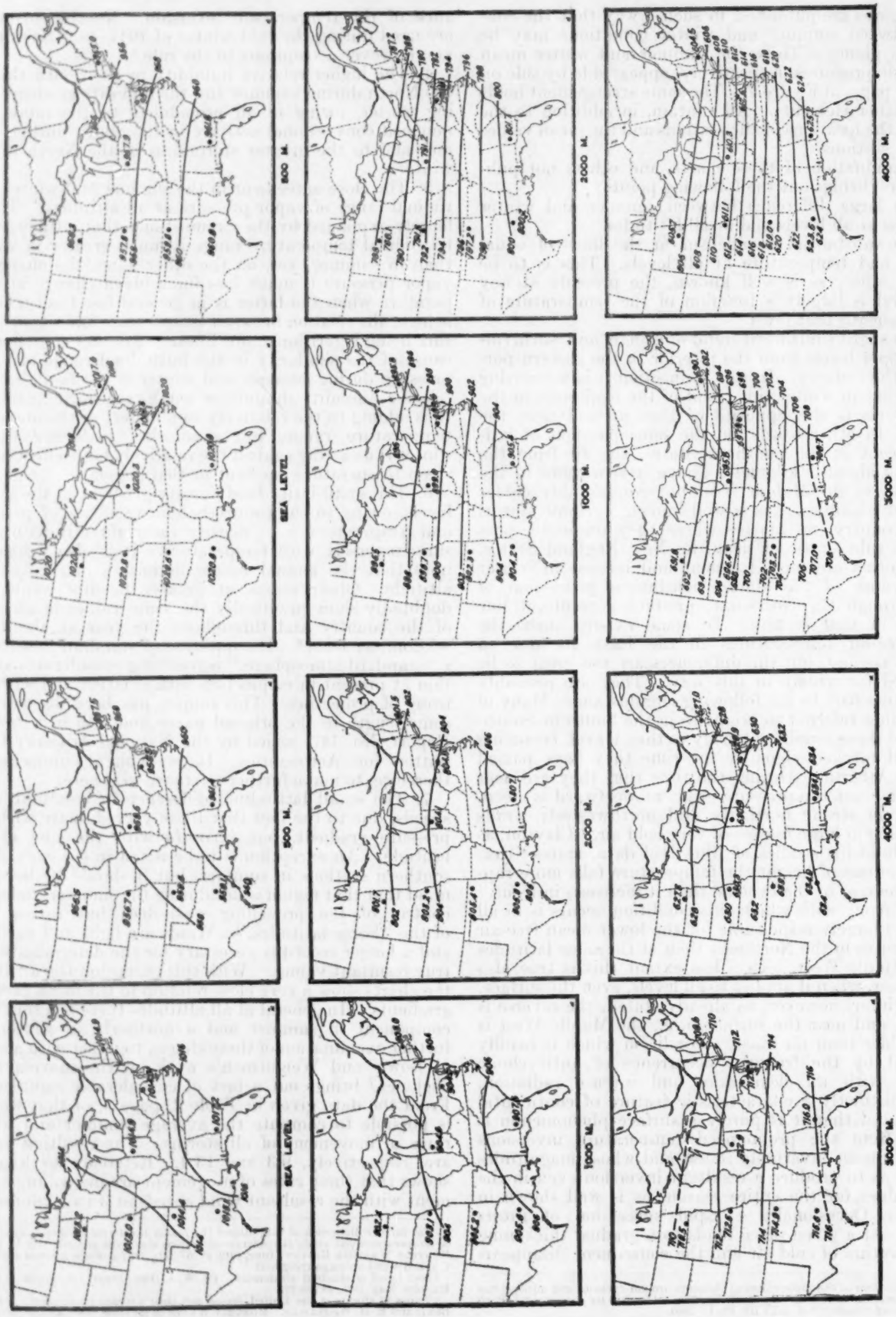


FIG. 2.—Mean summer and winter barometric pressures, mb, respectively, at specified levels over the eastern and central portions of the United States. Summer at left, winter at right.

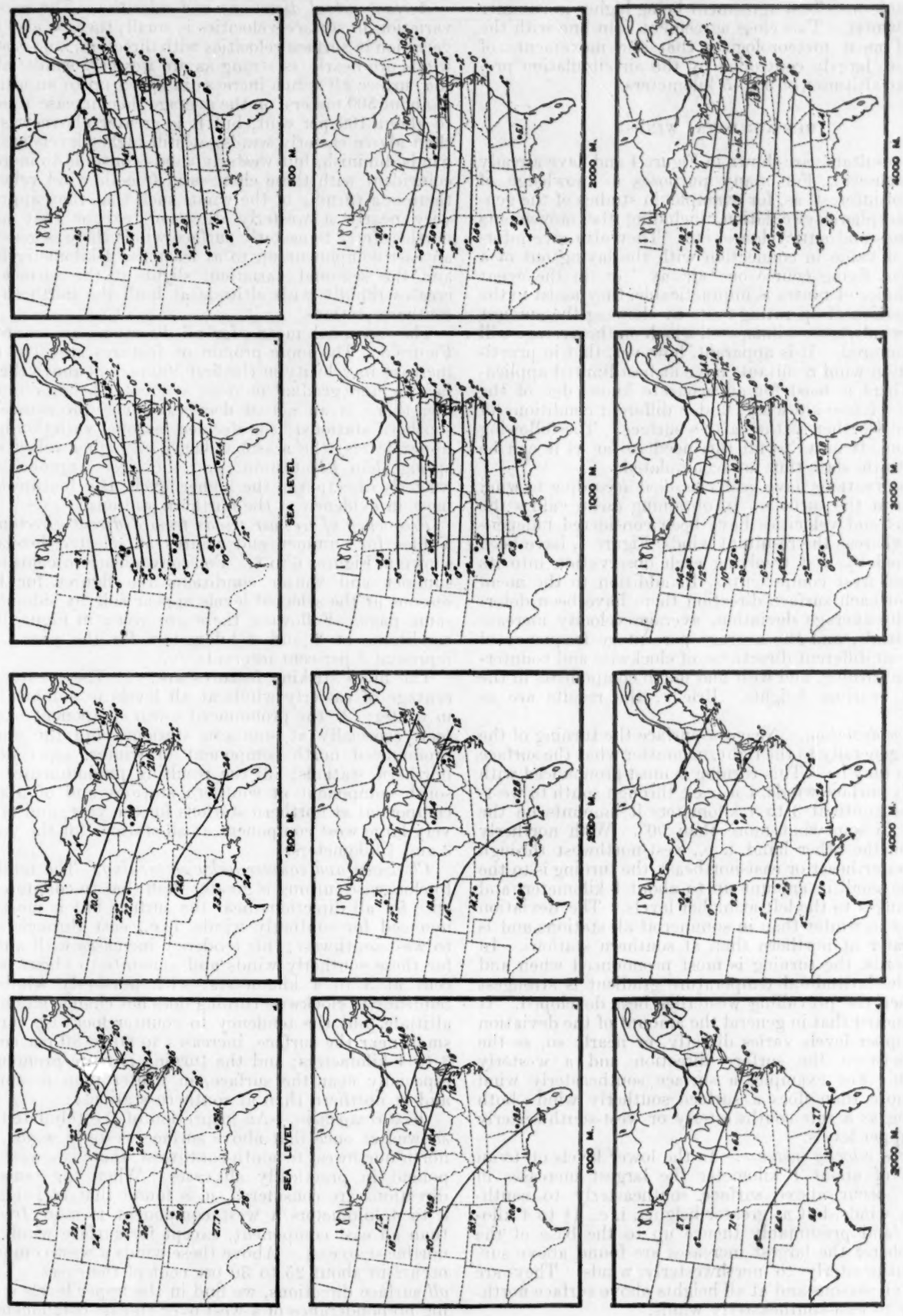


FIG. 3.—Mean summer and winter temperatures, (°C.) respectively, at specified levels over the eastern and central portions of the United States. Summer at left, winter at right.

the altitude with best agreement being higher in summer than in winter. This close agreement is in line with the belief of most meteorologists that the movements of storms are largely controlled by the air circulation prevailing at altitudes of 3 to 5 kilometers.

FREE-AIR DATA: WINDS.

Wind resultants are shown in Figure 4 and have already been discussed. For many purposes a knowledge of these is of interest, as, for example, in studies of the general atmospheric circulation, including the movements of cyclones and anticyclones, etc. They also give information of value in connection with the laying out of a permanent flying course or "airway," or, in the event that a choice of routes is impracticable, they assist in the determination of operating costs by showing the amount of head winds, cross winds, etc., which on the average will be encountered. It is apparent, however, that in practical aviation wind resultants have at best limited application. There is need for an accurate knowledge of the behavior of free-air winds under different conditions of wind and weather at the earth's surface. The following discussion attempts to fill this need so far as it can be filled with the data thus far accumulated.

All observations have been classified according to wind direction at the surface. In obtaining mean values the directions and velocities have been considered independently, whereas the resultant winds, Figure 4, have been determined by first resolving each observation into its north and west components. In addition to the mean values for each surface direction there have been determined the average deviation, average velocity increase with altitude, and the average percentage frequency of winds from different directions, of clockwise and counterclockwise turning, and west and north components in the winds at various heights. Briefly, the results are as follows:

Average deviation.—Near the surface the turning of the winds is generally to the right, no matter what the surface direction may be. This turning is most pronounced with southerly surface winds, i. e., east through south to west-southwest, until at 3 to 4 kilometers it amounts on the average to somewhat more than 90°. With northerly winds, on the other hand, i. e., west-northwest through north to northeast or east-northeast, the turning is to the right but small in amount up to about 1 kilometer, and then changes to the left at higher levels. The deviation is greater in winter than in summer at all stations and is also greater at northern than at southern stations. In other words, the turning is most pronounced when and where the latitudinal temperature gradient is strongest and hence the prevailing westerlies best developed. It is to be noted that in general the amount of the deviation in the upper levels varies directly, or nearly so, as the angle between the surface direction and a westerly direction. For example, a surface southeasterly wind turns more than does a surface southerly wind—both becoming as a rule southwesterly or west-southwesterly in the upper levels.

Average velocity increase.—In the lower levels up to an altitude of about 1 kilometer the largest increases in velocity occur above surface southeasterly to southwesterly winds, but at greater heights, i. e., 1½ to 4 kilometers (and presumably thence up to the base of the stratosphere) the largest increases are found above surface southwesterly to northwesterly winds. They are least in all seasons and at all heights above surface northeasterly to east-southeasterly winds.

Average actual directions and velocities.—The seasonal variation in surface velocities is small; there is also little variation in surface velocities with direction, i. e., easterly winds are nearly as strong as are westerly winds; above the surface all winds increase in speed up to an altitude of about 500 meters; on the average this increase amounts to about 100 per cent, but it is greater above westerly than above easterly winds; at still higher levels easterly winds diminish, but westerly winds continue to increase; coincident with these changes in free-air wind velocities there is a turning of the winds such that they approach very nearly a westerly direction, except that above northeasterly to easterly surface winds there is generally an east component up to at least the 4-kilometer level; and the seasonal variation, slight at the surface, increases rapidly with altitude at both the northern and southern stations.

The seasonal means for all directions are shown in Figure 5. The more prominent features are: The large increase in velocity in the first 500 meters above the surface; a more gradual increase at greater heights (in summer there is an actual decrease—most pronounced at southern stations); the decided seasonal variation in the upper levels; the seasonal lag, i. e., higher velocities in spring than in autumn; and the close approach to a westerly direction in the higher levels, this feature being most in evidence at the northern stations.

Frequency of free-air winds from different directions.—Values for summer and winter at selected levels are shown in Figures 6 to 8. For convenience in contrasting summer and winter conditions the figures for those seasons at the selected levels appear side by side on the same page. Following these are given in Figure 9 the conditions at 3 and 4 kilometers for the year. Arcs represent 5 per cent intervals.

The more striking features are: (1) The greater percentage of easterly winds at all levels in summer than in winter; (2) the pronounced south component in summer, especially at southern stations, and the equally pronounced north component in winter, especially at northern stations; (3) the resulting predominance of a south component at southern stations and of a north component at northern stations for the year; and (4) the very large west component at all stations for the year at 3 and 4 kilometers.

Clockwise and counterclockwise turning.—The tendency to clockwise turning is greater than that to counterclockwise for all directions near the surface but is most pronounced for southerly winds, i. e., east through south to west-southwest; this tendency increases with altitude for these southerly winds and amounts to about 90 per cent at 3 to 4 kilometers; with northerly winds the tendency to clockwise turning does not change much with altitude, but the tendency to counterclockwise turning, small near the surface, increases to 60 to 80 per cent at 3 to 4 kilometers; and the turning is more pronounced, especially near the surface, in winter than in summer and at northern than at southern stations.

West component.—An inspection of the tabulated data showed at once that above surface westerly winds, i. e., north-northwest to south-southwest, there is a west component in practically all cases. When the remaining directions are considered, it is found that at heights of 3 to 4 kilometers a west component is more frequent than an east component, except for surface winds from northeast to east. Above these winds a west component occurs in about 25 to 30 per cent of the cases. Taking *all* surface directions, we find in the upper levels a striking preponderance of a west over an east component, the

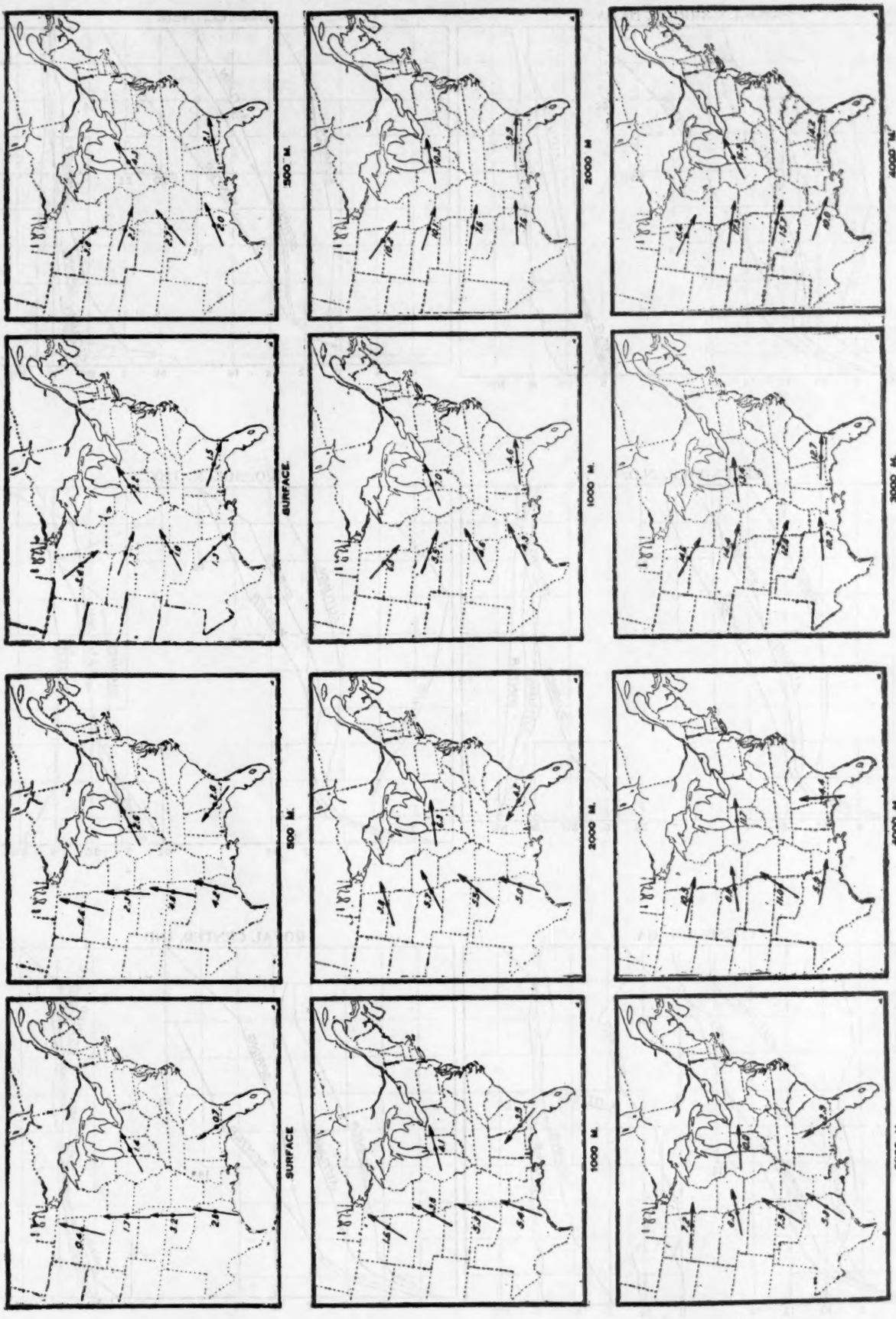


FIG. 4.—Mean summer and winter wind resultants, m. p. s., respectively, at specified levels over the eastern and central portions of the United States. Summer at left, winter at right.

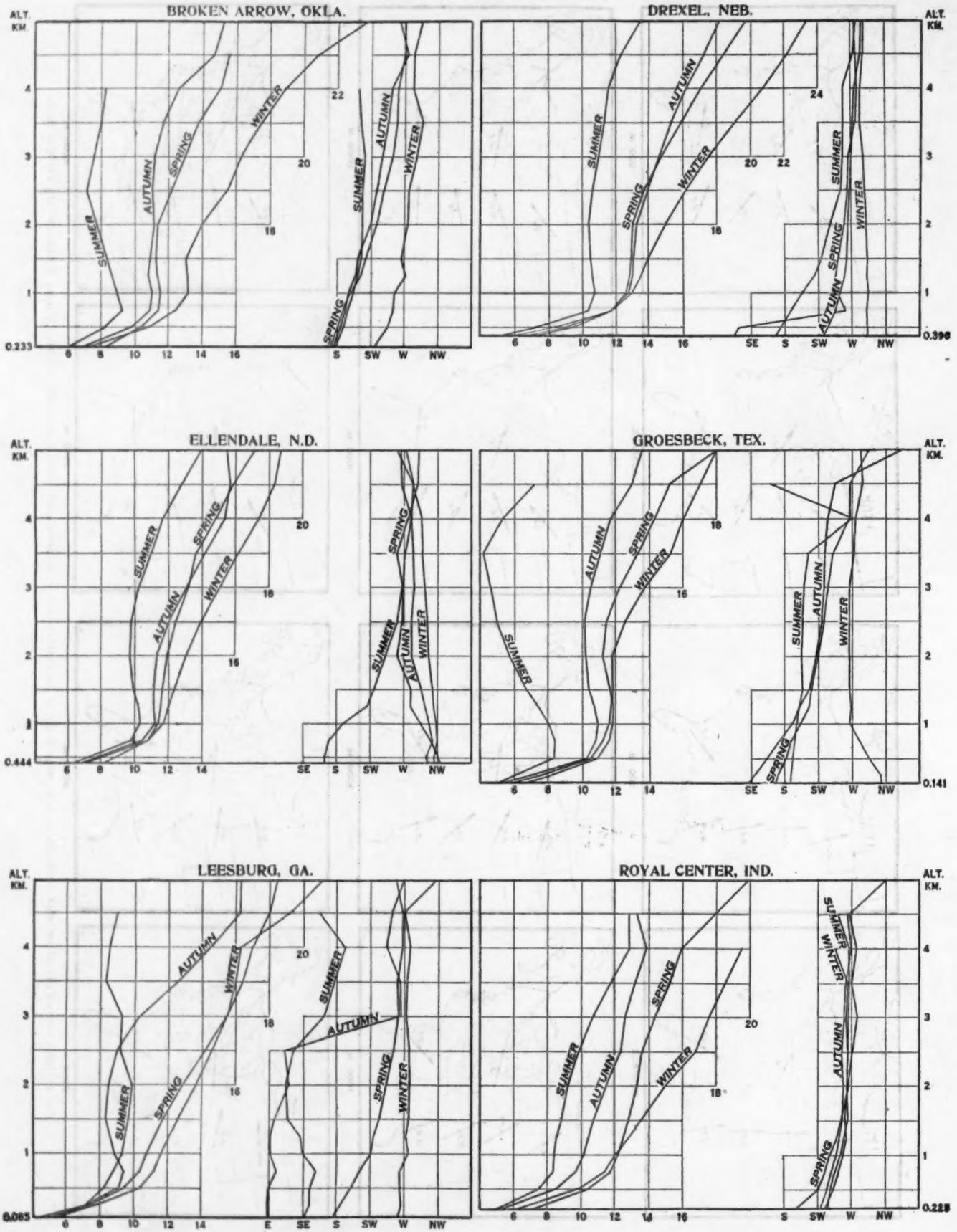


FIG. 5.—Mean seasonal free-air wind directions and velocities, m. p. s

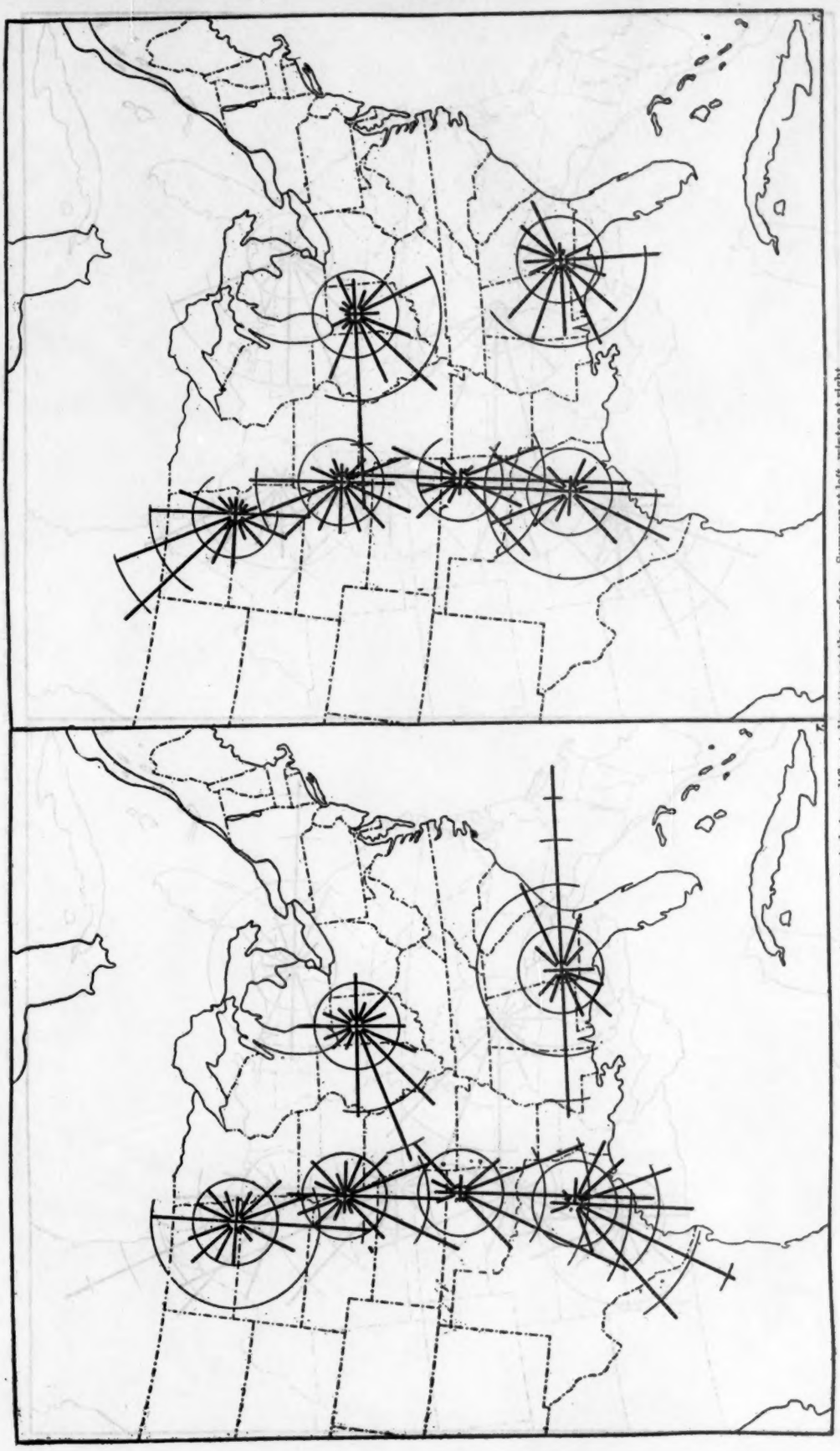


FIG. 6.—Percentage frequency of winds from different directions at the surface. Summer at left, winter at right.

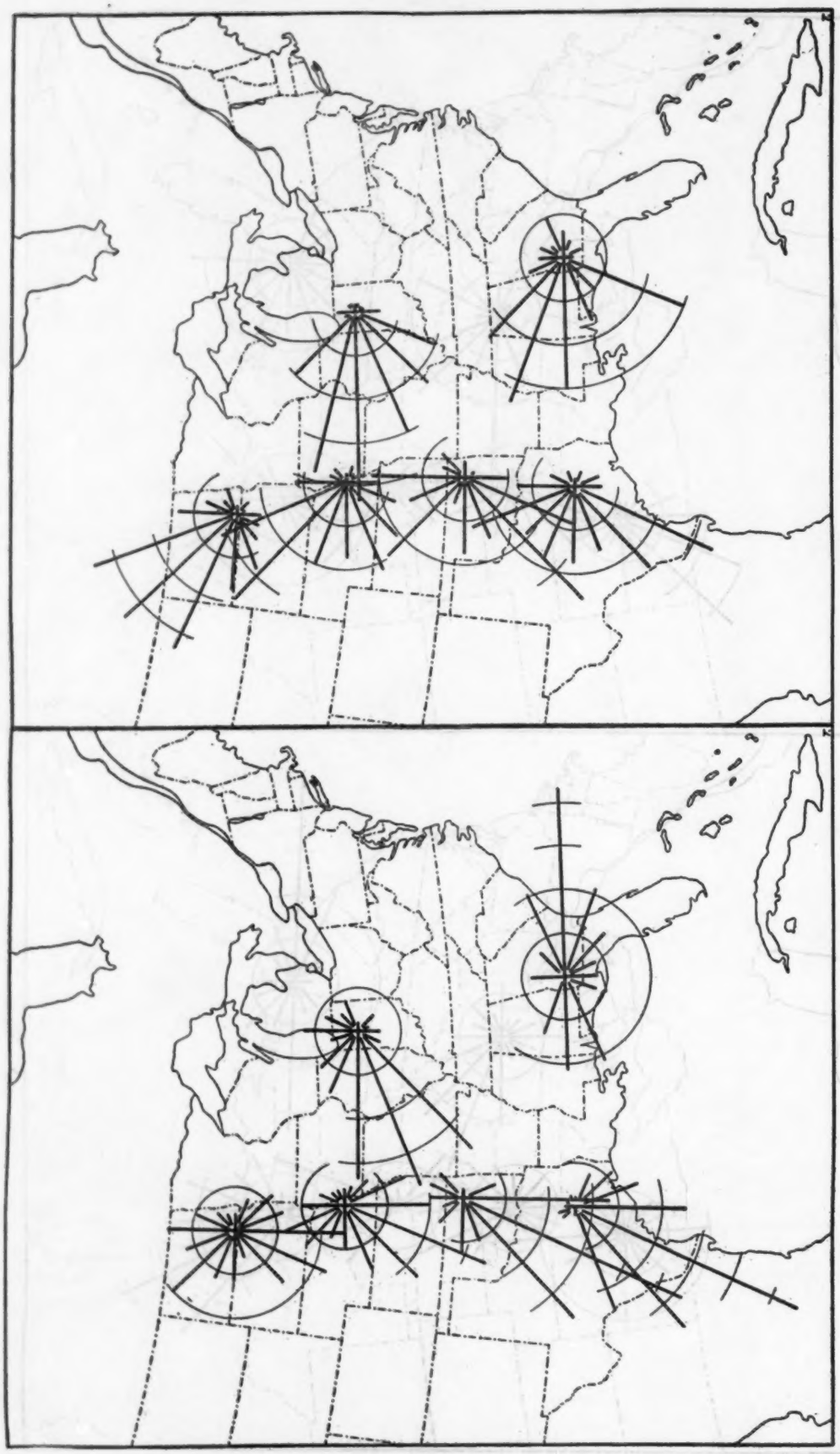


FIG. 7.—Percentage frequency of winds from different directions at 1,500 m. Summer at left, winter at right.

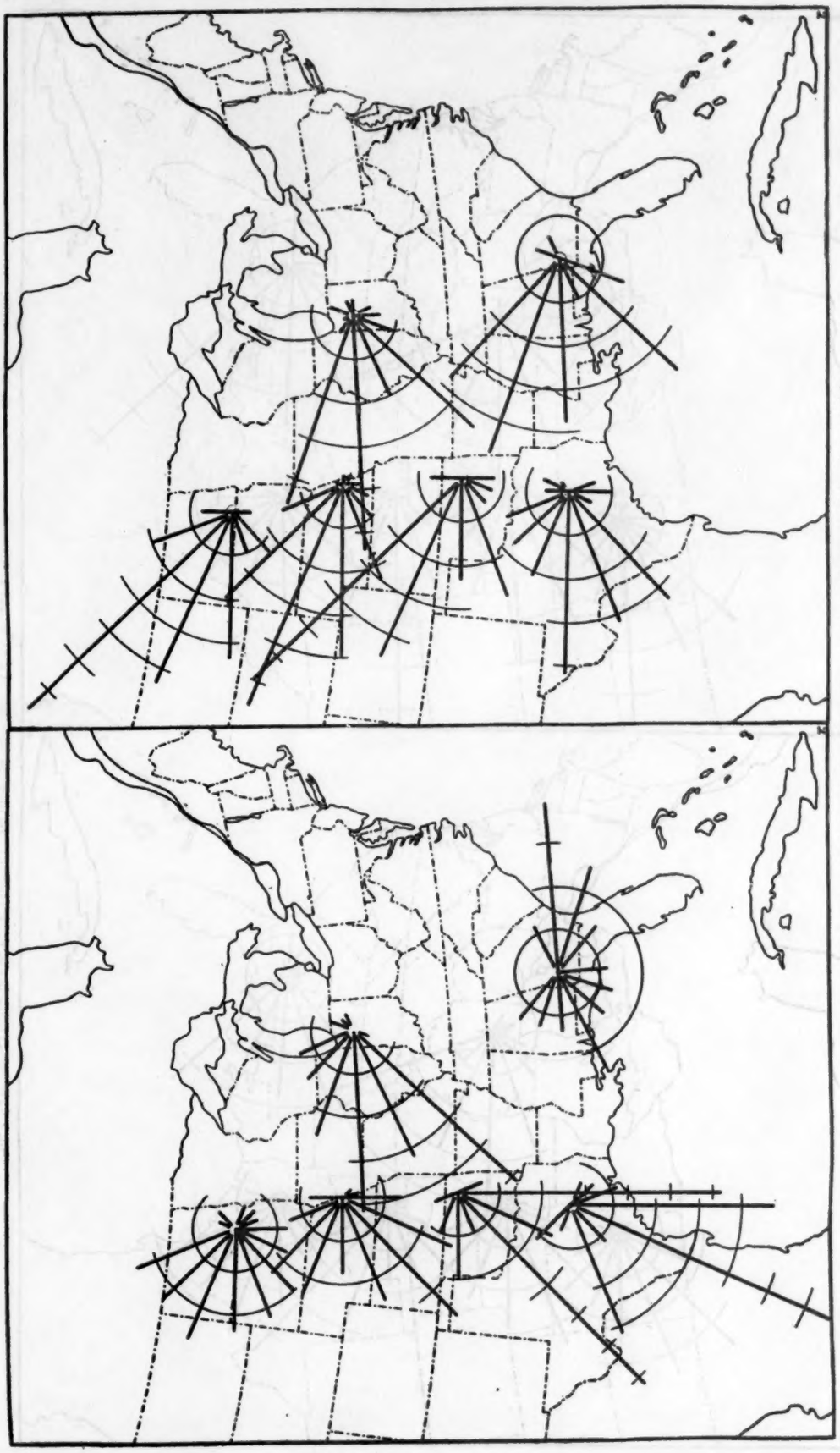


FIG. 8.—Percentage frequency of winds from different directions at 3,000 m. Summer at left, winter at right.

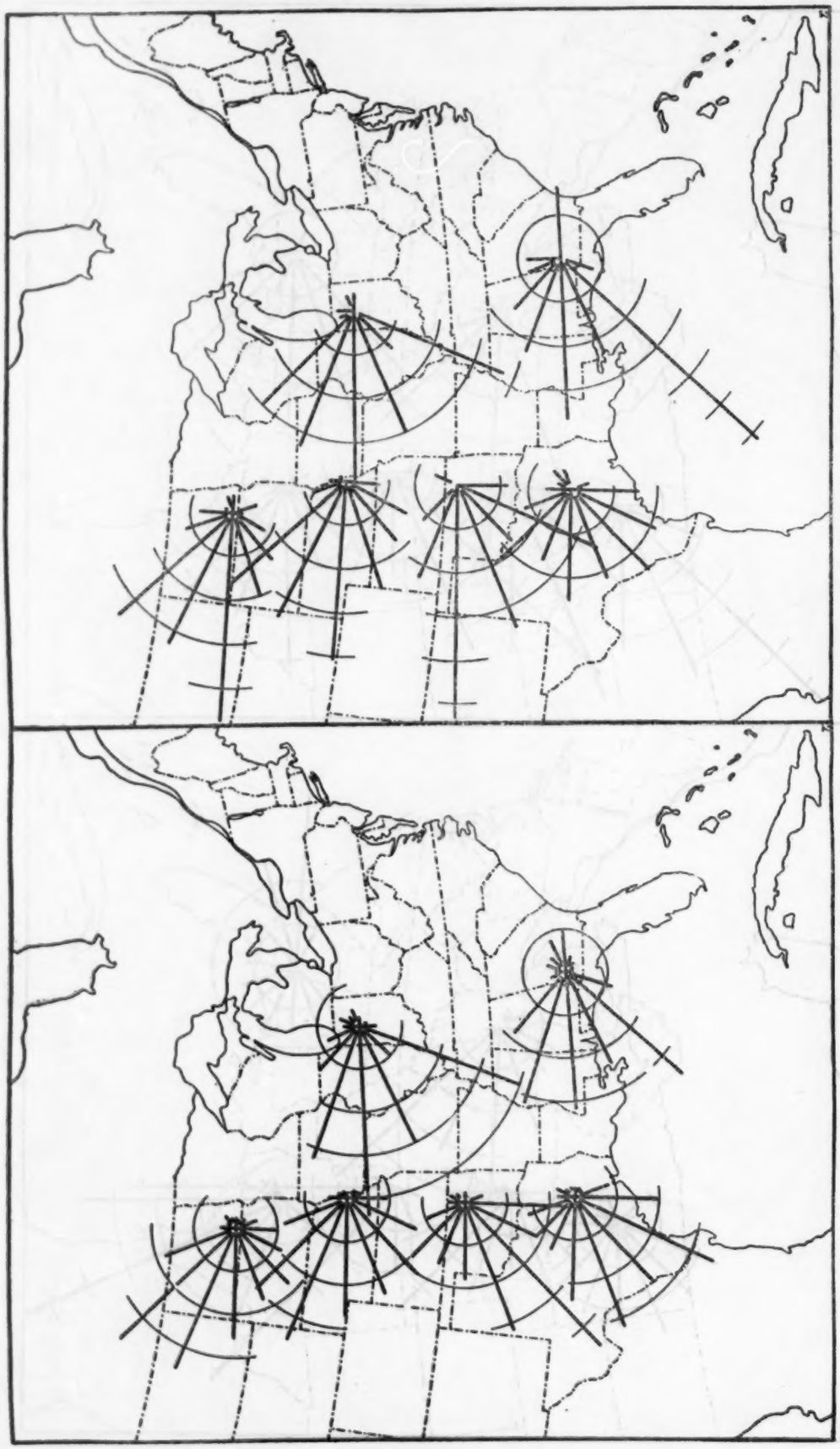


FIG. 9.—Percentage frequency of winds (annual) from different directions at 3,000 m. and 4,000 m., the former at left, the latter at right.

annual values being 89 per cent at 3 and 94 per cent at 4 kilometers. This percentage is somewhat greater in winter than in summer and at northern than at southern stations.

North component.—The data indicate that a north or south component in the surface winds persists in a majority of cases in the upper levels, except that above a surface east-northeasterly wind a south component is the more frequent and above a southwesterly or a west-southwesterly wind a north component predominates. Other features are the pronounced south component in summer, especially at southern stations, the equally pronounced north component in winter, especially at northern stations, and the resulting predominance of a south component at southern stations and of a north component at northern stations for the year.

General remarks.—The foregoing discussion of wind data and the conclusions given should be accepted with the reservation that they are based upon observations that were made only under conditions favorable for kite flying, i. e., surface winds ranging from 2 to 20 m. p. s. and upper winds ranging from 5 to 35 m. p. s. Thus it will be seen that conditions closely approaching a calm are not represented. In other words, data are lacking for days on which there was no appreciable pressure gradient. This explains the somewhat higher velocities and the slightly larger percentage frequency of a west component given in this summary than in a previous study based upon observations with pilot balloons.[8] It should be remembered, though, that pilot balloons are observed to best advantage in light winds, since they soon disappear in the distance when winds are strong. Moreover, they can not be observed at all in clouds, whereas kite flights are frequently made in cloudy weather and occasionally even when light rain or snow is falling. All things considered, then, it seems that the results obtained with kites come nearer representing all conditions than do those with balloons. In any event, they are certainly representative of the conditions that prevail most of the time, viz, moderate winds in both clear and cloudy weather.

[8] Reihle, J. A. Flying weather in the Southern Plains States. MONTHLY WEATHER REVIEW, November, 1920, 48:627-632.

RELATION BETWEEN RATE OF MOVEMENT OF ANTICYCLONES AND THE DIRECTION AND VELOCITY OF WINDS ALOFT (WEST AND SOUTHWEST OF HIGHEST PRESSURE).

By CHARLES L. MITCHELL.

[Weather Bureau, Washington, D. C., April 25, 1922.]

The importance of anticyclones in the control of weather conditions and the desirability of accurate knowledge as to whether they will move rapidly or slowly or remain practically stationary has long been recognized by forecasters. The surface conditions as shown on the daily weather maps do not always supply all the data necessary for making accurate predictions of the movement of anticyclones. It has been evident from a day-to-day inspection of the charts of wind direction and velocity at the several levels above the earth's surface at the various aerological stations of the Weather Bureau, the Army, and the Navy that the action of anticyclones depends to a large extent on the conditions shown at 2,000 to 4,000 meters, or even higher, above sea level. A study has been made, therefore, of the aerological charts of wind direction and speed in free air from pilot balloon flights from the time their preparation was begun in October, 1920, to the end of March, 1922, in connection with the rate of movement of anticyclones. In all, 62 anticyclones over the eastern half of the United States were studied, and they were classified (1) as to place of first appearance on the weather map, and (2) in relation to free-air wind direction and velocity at or above 2,000 meters to the west and southwest of the crests of the anticyclones, when available. Free-air observations below the 1,000-meter level were not considered in this study.

In general, it may be said that the rate of movement of the anticyclone is roughly proportional to the speed of the free-air winds at and above the 2,000-meter level. The results of the study are shown in the table below.

TABLE 1.—*Free-air winds and anticyclonic movement.*[1]

Winds west and southwest of crest of HIGH, usually at 2 km. to 4 km.	Type of anticyclone.			Total.
	Pacific.	Alberta or Manitoba.	Hudson Bay.	
Fresh to strong SW. winds. HIGH moved rapidly east or northeast	10	15	1	26
Same, except moderate SW. wind	0	4	1	1
Moderate SW. winds in south and fresh to strong southwest in north. Axis of HIGH changed from N.-S. to NE.-SW. Barometer fell slowly in the southeast	0	10	0	10
Fresh to strong SSW. to W winds. HIGH moved eastward with normal speed	3	8	0	11
Moderate to fresh S. and SW. in north, moderate SSE. to SSW. in south. Normal speed	1	1	0	2
Strong NW. in east and SW. from Texas northward. Deep low over Newfoundland. HIGH slow mover	0	2	1	3
W. winds in north, SW. in south. HIGH slow mover	1	0	0	1
Gentle to moderate SE. and S. winds. HIGH very slow mover	0	1	0	1
Fresh SW. winds. HIGH of great magnitude. Slow mover	0	2	0	2
Easterly winds aloft. Stationary HIGH	1	3	1	5
Total	16	42	4	62

[1] The term "HIGH" is used throughout this table as synonymous with "anticyclone."

In practically every case where the winds aloft were fresh to strong southwest both to the southwest and west of region of highest pressure, the anticyclone moved eastward or northeastward rapidly (in 26 instances) or at least at a normal rate of speed (in 11 instances). The only exceptions were on January 7 and March 16, 1922, when the anticyclones were of great magnitude and

moved slowly eastward, although there were fresh southwest winds aloft to the west and southwest, and on October 29 and December 21, 1920, and January 2, 1922, when there was a deep stationary cyclone over Newfoundland and the winds aloft over the northeastern States were strong northwest. All of these 5 anticyclones moved slowly.

It is quite interesting to note that when Alberta or Manitoba anticyclones reach the eastern States with major axis north-south and fresh to strong southwest winds set in aloft, say from Oklahoma northward and north-eastward, but remain only moderate southwest aloft over the Gulf States, the direction of the major axis is invariably shifted from north-south to northeast-southwest, the southern end remaining almost fixed in position, i. e., pressure decreases rapidly east of the upper Mississippi Valley and a cyclone moves eastward over this region, while the barometer falls very slowly over the southeastern States and generally rises at Hamilton, Bermuda. If, at the same time, there is a deep stationary cyclone in the vicinity of Newfoundland, the northern end of the anticyclone will disappear entirely (see map of Feb. 15, 1921). This condition is peculiar to anticyclones that move southeastward from Alberta or Manitoba. One anticyclone, that of December 30, 1921, was originally tabulated as of Pacific origin, but being the only one, a further investigation was made and it was found that, while it originally appeared on the Pacific coast, it was reinforced from the Canadian Northwest on December 28, thereafter partaking of the nature of an Alberta anticyclone. It has been found from previous observation and from this study that whenever a Pacific anticyclone is reinforced by an anallobar moving down from the Canadian Northwest it becomes an Alberta anticyclone in fact; furthermore, if either a Pacific or an Alberta anticyclone is reinforced from the Hudson Bay region its future course is the same as if it came originally from that region.

It will be observed that each of the five stationary anticyclones was very deep and controlled the upper winds far to the westward. A striking example was the anticyclone of the last week in October, 1921, the note made in connection with it being as follows:

October 25.—Anticyclone 30.3 [inches] over Ontario. Moderate to fresh east and southeast winds aloft from Lansing and Royal Center westward. Gentle southwest winds in west Gulf States. Anticyclone moved slowly southeastward over northeastern States, then remained stationary with lessening intensity until end of month. Stationary cyclone over Newfoundland. Winds aloft remained southeast to northeast at Royal Center during entire period and two Colorado disturbances of marked intensity were retarded, partially filled up, and diverted from normal path.

As a result of this study and of the day-to-day examination of the aerological charts the writer is convinced that, given sufficient upper-air observations, the forecaster can predict with a great deal of confidence the future course and the rate of movement of practically every anticyclone.

HIGH-LEVEL ISOBARS AS USED IN EVERY-DAY WEATHER SERVICE.

By RIKICHI SEKIGUCHI.

[Cambridge, England, Apr. 5, 1922.]

NOTE.—Through the courtesy of Prof. V. Bjerknes, Doctor Sekiguchi has kindly prepared for the REVIEW the paper which he delivered before the International Commission for the investigation of the Upper Air held at Bergen, Norway, July 25-30, 1921.[1] Doctor Sekiguchi has had extensive experience in the application of maps of free-air pressure [2] to forecasting in Japan.—EDITOR.

The present communication is a short summary of the author's two years' experience in his weather service, in cooperation with Dr. S. Fujiwhara and Dr. Y. Horiguchi, at Osaka and Kobe. Several trials in the use of high-level isobars were made with the hope of finding some help for predicting the change of weather type with greater certainty than the ordinary synoptic charts alone can afford. At first (the spring of 1918), the 1,000-meter level was chosen for daily use and proved itself very useful in predicting movements of cyclonic centers. Later on, charts for the 3,000-meter level were added to the scheme and even 6,000-meter isobars were drawn occasionally. But after some experience having found the 3,000-meter chart most useful, the author confined his attention mainly to that level.

In drawing isobars, the values of pressure on the respective levels must be entirely based on the observed surface values of certain meteorological elements and certain assumptions concerning the lapse rate of temperature. The method of drawing isobars had nothing different from that which is being generally used in making ordinary synoptic charts, except that on the high levels there was no information concerning the wind to be taken into account in checking the trend of isobars, as is usually done on the sea-level chart.

At first the complexity of the trend of the isobars as influenced by local abnormality of surface air temperatures was a perplexing feature. But as the author became somewhat experienced in this method he could get rid of this complexity to some extent by making due allowances for the abnormalities that might be estimated to some degree from the topographic conditions, temperature changes, the state of the sky, etc. After some study it has been found that the general trend of the upper isobars in general was not so much affected by the actual lapse rate being unknown as it was at first feared. The remaining abnormalities seemed to have caused no great disturbances in considering the general trend of isobars in the majority of cases. Moreover, for the sake of safety, the high-level charts were based on the data from coast stations only, as far as it was possible, in view of minimizing the effect of surface inversion. Some of the results of investigations are summarized as follows:

(1) The movements of cyclonic centers in the Far East showed in most cases fair accordance with the general trend of the 3,000-meter isobars,[3] showing the less dependence upon the trend of sea-level isobars.

(2) The region where the general trend of both systems of isobars (free-air and sea-level) ran nearly parallel to each other was never passed by a cyclone which happened to be in the neighborhood at that moment. This fact seems to be in fair accord with the current idea that cyclones tend to be drifted by the prevailing upper-air current, if the upper isobars are assumed as identical with the stream lines on that level.

(3) When both systems of isobars ran nearly parallel on three sides—that is, on the front, right, and left—of the path of the cyclone, that cyclone was observed to be generally stationary. Similar phenomena were almost invariably observed when the wedges of high pressure

[1] Cf. *Proceedings*, p. 23.
[2] Cf. Fujiwhara, S.: Pressure maps at 3 kilometers in Japan. MO. WEATHER REV., Oct., 1921.

[3] Mr. C. L. Mitchell points out numerous similar cases where anticyclonic movement in the United States was in agreement with the direction and speed of upper currents. This REVIEW, pp. 241-242. EDITOR.

areas pressed upon the front of the cyclone from both sides of the track. The space between the wedges was called "the gate of the cyclone" because typhoons showed a tendency to move toward the "gate" but could not make any remarkable advance as long as the "gate" remained shut; it rushed through as soon as the "gate" was opened.

(4) Most cyclones showed decided tendencies to move toward the region where unmistakable cross-intersections of upper and lower isobars could be perceived. These "crosses" also indicated the weather declining there most rapidly, while in the region of "parallel" the weather usually continued to be fair.

(5) Two different classes of "crosses" have been distinguished: One, indicative of a lower drift, turned 90° counterclockwise from the direction of the upper drift, and the other indicative of the opposite turning. The cyclone-attracting tendency of the "crosses" was shown only by the former class, while the latter indicated the weather clearing up. The former class, however, did not show its full effect unless the upper drift seemed to be of warm origin. The former was sometimes referred to successfully as the reliable foreteller of a cyclone being formed at some distance.

(6) As a result of statistical study it was shown that moving anticyclones in the neighborhood of Japan have general tendencies to move the more rapidly, the more prominently appear the "crosses" on the rear of them.

(7) By means of the isobaric charts for successive heights the thickness of anticyclones has been estimated, and it was found that very thick [vertical depth] HIGHS persisted fairly long, while very thin ones faded away in a short time.

(8) The observations of pilot balloons generally showed fair accordance with the trend of upper isobars except when the station (Kobe) happened to be near the point of sharp recurvature of isobars.

(9) The existence of the surface of discontinuity has been indicated and its height at the point of observation fixed with fair accuracy by means of pilot-balloon observations. Sharp bending of the trajectory attended by sudden change of wind speed has been taken as a sign of transition between two distinct drifts, one over another. Shortly after such a surface of discontinuity a change from anticyclonic to cyclonic type of weather was usually perceived, especially when the abrupt change of wind direction from some easterly point to southwesterly point at some height near 3,000 meters was observed. Steady northwesterly, northeasterly, or southwesterly winds, retaining those directions up to several thousand meters without any remarkable change, seemed to suggest the persistence of anticyclonic weather.

(10) In the colder season, so long as the general trend of the upper isobars in the East China Sea and the Yellow Sea was from some northwesterly to southeasterly point, the general weather conditions in Japan were good and steady. As the weather declined they gradually changed to horizontality—that is, west to east trend. Finally the trend became directed from some southwesterly point to northeasterly as a continental cyclone approached the east coast of China. The whole appearance of the chart of upper isobars gives an impression of a wavy system moving slowly from west to east. In many cases watching such movement was very helpful to the author in seizing upon the first sign of cyclonic approach.

(11) Nearly opposite directions of upper and lower isobars during the winter monsoon rains in the East China Sea should be taken into account in the explanation of that phenomenon which was formerly explained simply by the orographic effect. The fairly strong and steady southwesterly wind prevailing thereabout (and also along the Pacific coast of Japan proper) in summer, with the upper and lower isobars in the same direction, does not generally bring about continued rain like that of the winter season.

(12) There have been many instances of heavy rain which can be suitably explained only by supposing the existence of instability that may have been arising from the invasion of a cold drift of air over a warm one, as shown by the trend of upper and lower isobars.

Thus I have summed up my experience briefly. Reflecting upon the method used, the weakest point lies in the uncertainty of the lapse rate. Notwithstanding, we have proceeded with our eyes closed to it, for a while, in eagerness to raise the percentage of successful forecasts on any reasonable ground, leaving further refinements and improvements of the method to later investigations.

DISCUSSION.

American meteorologists will appreciate this generous act of Doctor Sekiguchi in pausing from his busy European visit to commit to writing these precepts for forecasting from free-air isobaric charts, as determined by Japanese experience. The intrinsic merit of such charts which represent (when accurately drawn) *real* conditions, in contrast with *hypothetical* conditions shown upon the sea-level charts, has long been recognized. But the difficulty of correctly estimating the temperature conditions in the free air has led to the general acceptance of sea-level as a reduction plane, it being much easier for us to have faith in the temperature of an air column which does not exist than in one which does, when actual measurements are not possible. We have chosen, rather, to "bear those ills we have, than fly to others, that we know not of."

But the accessibility of aerological data in constantly-increasing quantity has given rise to an unmistakable tendency for forecasters to give attention to free-air conditions, with a view to adapting the information thus gained to the improvement of the current forecast. In a country so large as the United States, where so many influences are operative, it is far from easy to read at once the significance of these free-air phenomena. This practical message of Doctor Sekiguchi comes, therefore, at once as a challenge and as an encouragement to those who look to the free-air for forecasting aids.

The process of collecting aerological information at numerous well-distributed stations is an expensive one, and the desirability of basing the free-air map upon surface conditions is apparent. The method used in Japan is clever; but, as Doctor Sekiguchi shows, it is chiefly applicable to the stations subject to marine influences. The short distance between the stations on the east and west coasts of Japan enables one to draw the isobars without giving much heed to the interior stations, which show the effects of an incorrect temperature argument. But we, in the United States, can not escape the difficulties so easily, because of the relative paucity of, and great longitudinal distance between, coastal stations. The problem is to find a way that will satisfy our needs.

Doctor Sekiguchi's paper, while perhaps not offering a group of precepts that we can take over bodily and apply to our work, does remove, in a large measure, whatever anxiety we may have had as to the usefulness of such charts and allows us to concentrate upon producing something that will help us as much as the Japanese maps have helped the forecasters at Osaka, Kobe, and Tokyo.—*C. Le Roy Meisinger.*

VERTICAL DISTRIBUTION OF AIR CURRENTS IN DIFFERENT PARTS OF CYCLONES AND ANTICYCLONES.

By P. MOLCHANOV.

[Pawlowsk Aerological Observatory, March 5, 1922.]

[Translated from the German by EDGAR W. WOOLARD.]

Under the designation "Group *B*" will be included those types of vertical distribution of winds characterized by constancy of wind direction with increase of height. Such a condition implies that no temperature changes are going on in the air currents involved.

Type *B* is that along the edges of stationary or slow-moving anticyclones when no region of low pressure is in the neighborhood; it is characterized by low velocities and constant direction up to great heights. Type B_0 occurs along the edge of anticyclones when there is a more or less marked cyclonic area near by; the influence of the latter is manifested in a gradual increase of velocity with height. Type B_1 is that which exists in the right section of cyclones, and is distinguished by strong winds (of unchanging direction) in the higher as well as in the lower strata; Type B_2 occurs in the right section of secondaries and differs from Type B_1 in having a maximum at the height of 500 to 2,000 meters.

The significant feature of the types of Group *B* is the absence of temperature changes in the given currents. The observations made at Dickson Island (latitude 73° 30′ 28″ N., longitude 80° 23′ E.) when such conditions prevailed, give for the mean temperature change (at the surface) during the following 54 hours 0° with a mean deviation of ±0.5° and for the mean pressure change in the following 24 hours 1.4±2.6 mm. Precipitation occurs on Dickson Island only with southerly winds. Accordingly, the meteorological conditions attending Type *B* may serve to characterize the climatology of a region. Types B_0, B_1, and B_2 have an importance for synoptic meteorology, because the associated cyclonic region travels in the direction of the given wind circulation. If such a distribution of winds is observed in a direction other than that in which the cyclone is progressing, we may confidently count on a change of direction of the cyclone and its motion according to the observed circulation.

If a warm current is raising the temperature in the free air, then there is a gradual turning to the right of wind direction with increase of elevation; the velocities are moderate (8–10 m/sec.). These winds will be designated as belonging to Group *A*.

Type *A* occurs in the rear (west section) of anticyclones, associated with warm, uniform, weather. The approach of a cyclone is heralded by a strengthening of the winds in the upper strata; the stronger the upper wind, the deeper and more energetic the advancing cyclone. The distribution of winds on the forward side of an ordinary cyclone is characterised by an increase in the turning to the right and an increase in velocity up to 2,000 meters. The temperature changes which give rise to this group manifest themselves in the retarded rate of fall of temperature with increase of elevation, often accompanied by inversions or isothermal stretches. The observed clouds are usually of the layer or stratus forms; the diurnal variation of the wind ceases. The observations during such régimes at Dickson Island give the mean pressure change during 40 hours as 13±9 mm., and the mean temperature change during 46 hours as 9.5°±6.0°.

On the other hand, a fall of temperature is associated with a turning to the left, Group *C*. In cold waves from the north, this turning develops, often markedly, in the lower layers (Type *C'*); but in most cases, since cold waves lack anticyclonic structure, the turning takes place in the upper layers. Because of the rapid movement of cold waves, tremendous velocities often develop in the upper air (40–50 m/sec.). At Dickson Island the mean pressure change in cases of this group during 44 hours was 8.4±4.5 mm., and the mean temperature change during the same time, −5.4°±4.0°. In this type there is a strong decrease of temperature with height, the winds are gusty, and the clouds of the heaped-up types.

Type *D* occurs on the left side of cyclones; the lower wind (ordinary east wind) becomes, at 3 or 4 km., the general circulation with which the cyclone moves. In the forward parts of troughs there develops a wind distribution characterized by the change of the turning to the right in the lower layers to a turning to the left in the upper air, at 3 to 4 km.

FREE-AIR WINDS AT BAYONNE.[1]

By J. ROUCH.

[Abstracted from *L'Aérophile*, Apr. 1–15, 1922, pp. 105–110.]

About 180 observations with pilot balloons were made at Bayonne in 1918. All of these reached 4,000 meters, but above that level the number decreased rapidly, being only about 40 at 9 and 10 kilometers. The data have been classified in various ways for the purpose of showing for example, the diurnal variation, frequency of different directions, clockwise and counterclockwise turning, etc. The seasonal variation is not discussed, however, nor are we informed as to the distribution of the observations through the year, whether good or poor. Tables and figures bring out well the various points discussed. The principal features are:

1. At the surface easterly winds are nearly as frequent as are westerly winds; at 1 and 2 kilometers the prevailing directions are S. and SW., but NE. and E. are also well represented; above 2 kilometers westerly winds predominate, the percentage frequency of NW. to SW. being 55 per cent at 4 kilometers and 69 at 8 kilometers.

2. Velocities increase on the average 100 per cent, from 3 to 6 m. p. s., in the first kilometer; there is a further increase, but less decided, from 1 to 4 kilometers where the average value is 10 m. p. s.; from this level to 10 kilometers the increase is slight, amounting to only 2.5 m. p. s.

3. The observations were regularly taken at 7 and 12 o'clock, G. M. T. When considered separately, they show the characteristic diurnal variation at the surface, where the velocities at 12 o'clock are about 2.5 m. p. s. higher than at 7, and the reverse variation above 200 m. At 400 m. the velocities in the morning are about 2 m. p. s. higher than at noon. The difference decreases from this height to about 3 kilometers, above which there appears to be no diurnal effect.

[1] *Etudes sur la haute atmosphère en France: Le vent en altitude à Bayonne.*

4. Below 2 kilometers velocities are about equal for all directions, but above this level S. to W. winds are decidedly the stronger—4 to 5 m. p. s. on the average.

5. An investigation of the turning of winds with altitude gives results which are best presented in a table. The winds were not considered individually, but in groups by quadrants. Values are given in percentages.

Altitude, meters.	Quadrants.							
	NE.		SE.		SW.		NW.	
	CW.	CCW.	CW.	CCW.	CW.	CCW.	CW.	CCW.
1,000 to 2,000	32	57	67	26	45	45	44	44
2,000 to 4,000	27	66	44	52	66	21	52	44

The values in this table bring out very clearly the large percentage of counterclockwise turning of northeasterly winds, most decided in the higher levels, and the equally large percentage of clockwise turning of southeasterly winds, most decided in the lower levels. The results compare favorably with those found in the United States.

6. The percentage frequency of velocity increase or decrease has been treated in a manner similar to that above employed, and the results are shown in the following table:

Altitude, meters.	Quadrants.							
	NE.		SE.		SW.		NW.	
	+	−	+	−	+	−	+	−
1,000 to 2,000	50	24	48	36	58	37	44	17
2,000 to 4,000	58	30	51	38	76	16	96	0

7. Thirty-one of the observations were made when the land and sea breezes were well developed, and these were studied with a view to determining to what height this type of circulation extends, also to ascertain any other facts of interest. The results indicate that the land and sea breeze effect is still in evidence on the average at about 2,500 meters; above that level the general circulation prevails, the average values at 4 kilometers being almost identical both as to direction and velocity. At the surface the sea breeze is the stronger; from 100 to 300 meters there is little difference between the two; but from 500 to somewhat less than 2,500 meters the land breeze has a speed about 2 m. p. s. greater than has the sea breeze. This, however, may be in part a diurnal effect. Compare discussion under 3.

8. The paper concludes with a discussion of winds in the stratosphere, but the results are inconclusive, owing to the small number of observations, there being only two above 14 kilometers. These, however, indicate lighter winds between 15 and 20 kilometers than either below or above those levels.—*W. R. G.*

THE METEOROLOGICAL ASPECTS OF THE THIRTEENTH NATIONAL BALLOON RACE.

By VINCENT E. JAKL.

[Weather Bureau Aerological Station, Drexel, Nebr., June 28, 1922.]

To describe the meteorological conditions affecting the flight of the balloons participating in the National Elimination Balloon Race held at Milwaukee on May 31, 1922, and attempt to explain the meteorological control of the paths of the balloons at the various altitudes in which they flew, it is necessary to take a retrospective view of the weather conditions prevailing over the country for a period of a few days. In this way, after the method of forecasting, the predominating features of the weather map—specifically the areas of high and low pressure—are given characters from their history, supplemental or as an aid, to classifying them as belonging to some more or less definite type.

The race was somewhat unique in the annals of free ballooning in that a variety of courses was open to the contestants, in directions ranging from northeast through east to southwest, according to the altitudes chosen by the pilots in which to fly. Only two courses, however, merited any consideration as a means for winning the race. These courses were in almost opposite directions, one at high altitudes in a northeastward direction toward the Gulf of St. Lawrence, and the other at low altitudes in a general southwestward direction. The fact that the winner of the race, Major Westover, in choosing the path toward the northeast, covered a distance that did not lack much of being twice that of the balloon winning second place, and in such a comparatively short time (17 hours), justified the opinion, based on surface and aerological observations, that the upper northeastward course was by far the preferable one. However, it is evident both from Major Westover's report, and from the comparatively short distances covered by the other pilots who chose the northeastward course, and their slow rate of travel, that the desirable altitudes for a long fast flight in this course were neither easy to attain nor to hold.

In the present status of facilities for furnishing meteorological and aerological information to aeronauts by which they are left largely to their own resources as soon as they have left the ground, credit can not be entirely arrogated to itself by the Weather Bureau for accomplishments in the air aided or induced by Weather Bureau information and advice. (In this connection, see comments on radio service in this race by Mr. Upson). The result of the race was therefore a fine tribute to Major Westover's ballooning experience and acumen in taking advantage of existing weather conditions. The fact that the other pilots fell far short of equaling Major Westover's record does not in the least detract from their ability or courage; their failure by comparison was largely, perhaps entirely, fortuitous and circumstantial, as the following analysis of the weather conditions will undoubtedly prove.

A reference to the weather maps preceding the date of the race shows a persistency of high pressure over Ontario and the Lake region dating from May 21. This high pressure appears to have been periodically replenished by HIGHS drifting in along the northern United States border. A characteristic of Hudson Bay HIGHS, already noted by students of aerology, is the depth of winds on their southern side, conforming in direction to the surface isobars. The stagnation of HIGHS over the Lake region, typical of Lake influence in spring and early summer, appears to build up a structure having similar characteristics, i. e., deep winds from an easterly direc-

tion on the southern side of the HIGH. It was therefore not surprising to find deep east winds extending to over 4,000 meters altitude at Milwaukee on May 27. A strong HIGH with its crest over eastern Canada, extended southward to about the Ohio Valley.

The influence of depth to this HIGH on the 27th had the following significance to the outcome of the balloon race on May 31: If the stagnation of high pressure on the Lakes and Ontario persisted, the flight of the balloons would quite likely be in a course that would carry them successively west, northwest, and possibly north, at a moderate speed, with the prospect of landing not much beyond the Canadian frontier at Manitoba. If the HIGH receded to join the Atlantic HIGH, and a low area supervened—as subsequently happened—winds from a southerly to southwesterly direction to a great depth might be expected, excepting that the winds in the lower levels and at the surface would depend on other modifying influences that might develop.

The high pressure that enveloped the Lake region on June 1, and whose front edge was already encroaching on Milwaukee on the afternoon of May 31, was first identified on the weather map as an Alberta HIGH on May 27, being apparently a reinforcement of the HIGH approaching the north Pacific coast on May 25. The characterization of this HIGH may be summed up as follows: A moderate Alberta HIGH losing intensity with southeastward progress; a northwestern LOW that antedated it on the weather map dissipating in its advance; continuous precipitation in its front; and a renewed tendency for the development of a LOW in its front, this time from the south, on May 29.

Owing to the cloudy weather and rains attending the advance of this HIGH, not much direct information was available as to the depth, strength, and direction of winds within it after it had reached the range of aerological stations in the Middle West. It is, however, characteristic of many HIGHS approaching from the Northwest that have no pronounced LOW in their front, to be shallow in the sense of depth of winds conforming in direction to that indicated by the surface isobars. In other words, HIGHS of certain type of intensity originating in the Northwest may be defined as having predominately west to northwest winds in their structure, with comparatively shallow north to east winds in their eastern and southern quadrants.

The analysis of this HIGH by type and aerological reports favored the belief that the winds in its front shown on the surface weather map were shallow, that it was gradually encroaching on an extensive deep area of moderate winds from a southwesterly direction, that the rains in its front were due to a rolling up or convection of the air in its front into the winds aloft that had a component from the south or southeast; and as a conjecture, strengthened by the appearance of the isobars on May 29—that a more or less well-defined LOW would develop in its front by May 30 or 31.

The existence of a great drift from the southwest parallel to a trough of low or indifferent pressure extending from the Lakes to Texas, suspected from the result of an upper-air observation at Milwaukee on May 29, was confirmed by more extensive reports on May 30. It should be noted that by this time the Lake HIGH was merging into the Atlantic HIGH. The inference is optional, according to the theory one is inclined to favor, as to whether the SW. to NE. drift was incidental to the Atlantic HIGH and the process of its increment by the Lake HIGH, or that the SW. to NE. drift was an entity, and the HIGHS and their behavior only a visible evidence of the interaction between this drift and an oppositely directed one. (See writings of Bigelow on countercurrent theory and Bjerknes on Polar Front.)

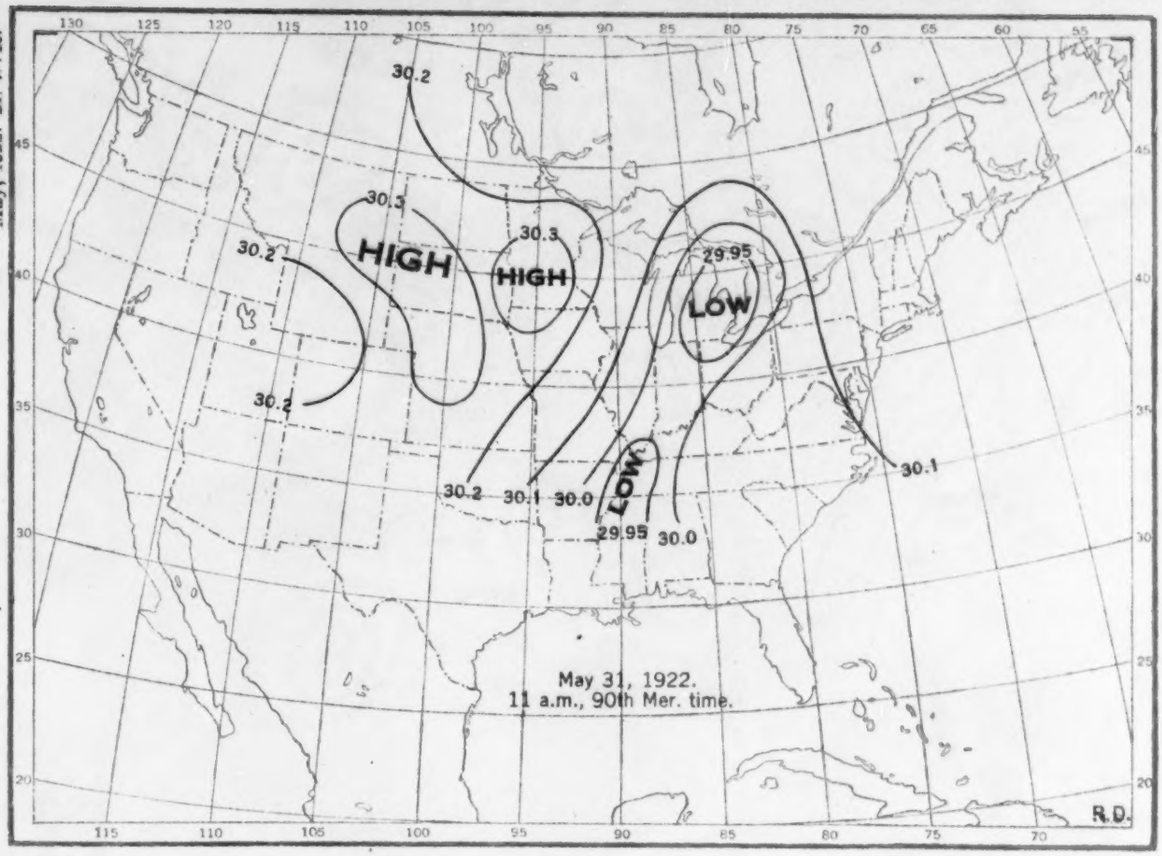
The weather map on May 30 showed a better defined trough of low pressure extending from the Lakes southwestward and strong indications of a low pressure center forming southwest of the Lake region. It therefore appeared on the 30th that conditions would approach a crux on the 31st—that while the southwesterly winds at high altitudes aloft would continue on the 31st, stronger, deepening winds from a northerly direction would prevail in the lower altitudes near the ground. The indications were also for unsettled weather and probably rain for the night of the 30th and the 31st.

The regular morning and special 11 a. m. weather maps on the 31st showed long straight isobars in front of the northwestern HIGH, extending from Milwaukee southwestward to Texas, although the 11 a. m. reports showed a preceptible weakening of the gradients along that line. Apparently, a balloon taking off at Milwaukee and maintaining an altitude of between 2,000 and 3,000 feet would have its destination in southern Texas. Actually there was no possibility of accomplishing such a long flight in that direction, owing to a number of inhibiting factors in the weather element and the practice of free ballooning. As the HIGH was weakening and changing its configuration, there would be no strong far-flung, unidirectional winds in its front composition; moreover, its nature indicated extremely variable wind directions and velocities with altitude. Under these conditions, the endurance of the pilots and the expenditure of ballast necessary to maintain a favorable altitude precluded the possibility of a flight that would necessarily have to be of long duration. (Note comments in reports of Lieutenant Reed and Mr. Honeywell.)

Aerological reports on the 31st showed the deep drift aloft from the southwest still prevailing over the clear area to the east and south of Milwaukee. The surface wind at Milwaukee was northeast to north, and weather cloudy and rainy to within an hour of the time the first balloon took off in the middle of the afternoon.

The upper air conditions on May 31 over Milwaukee, in the absence of direct aerological observation there, were construed to be as follows: A fresh wind from a northerly quarter, extending to about 2,500 to 4,000 feet, thence backing above the clouds through a shallow transitional layer of west wind to southwest at perhaps 6,000 feet, thence from a general southwesterly direction to an indefinite height. This is a typical arrangement of the winds above the clouded area in the rear of an elongated or crescent-shaped LOW extending SW.-NE. When the LOW is more constricted and the gradients in general steeper, there is a correspondingly increased strength in the oppositely directed winds aloft and below, with a still shallower transitional zone of wind from the west. Parenthetically, the analysis of such conditions shows the value of kite observations. In certain types of overcast weather the only available source of data of upper-air conditions is from the record of kite observations made under similar conditions, since it is often possible to penetrate the cloud layer with kites and extend the observation to considerable altitudes above.

The series of aerological reports from the morning of May 30 to 11 a. m. May 31 showed that, although the deep SW.-NE. drift aloft was quite weak, the winds increased in force with altitude and to a slightly perceptible extent with time. It therefore seemed evident


30.2
30.3
HIGH
30.3
HIGH
30.2
29.95
LOW
30.2
30.2
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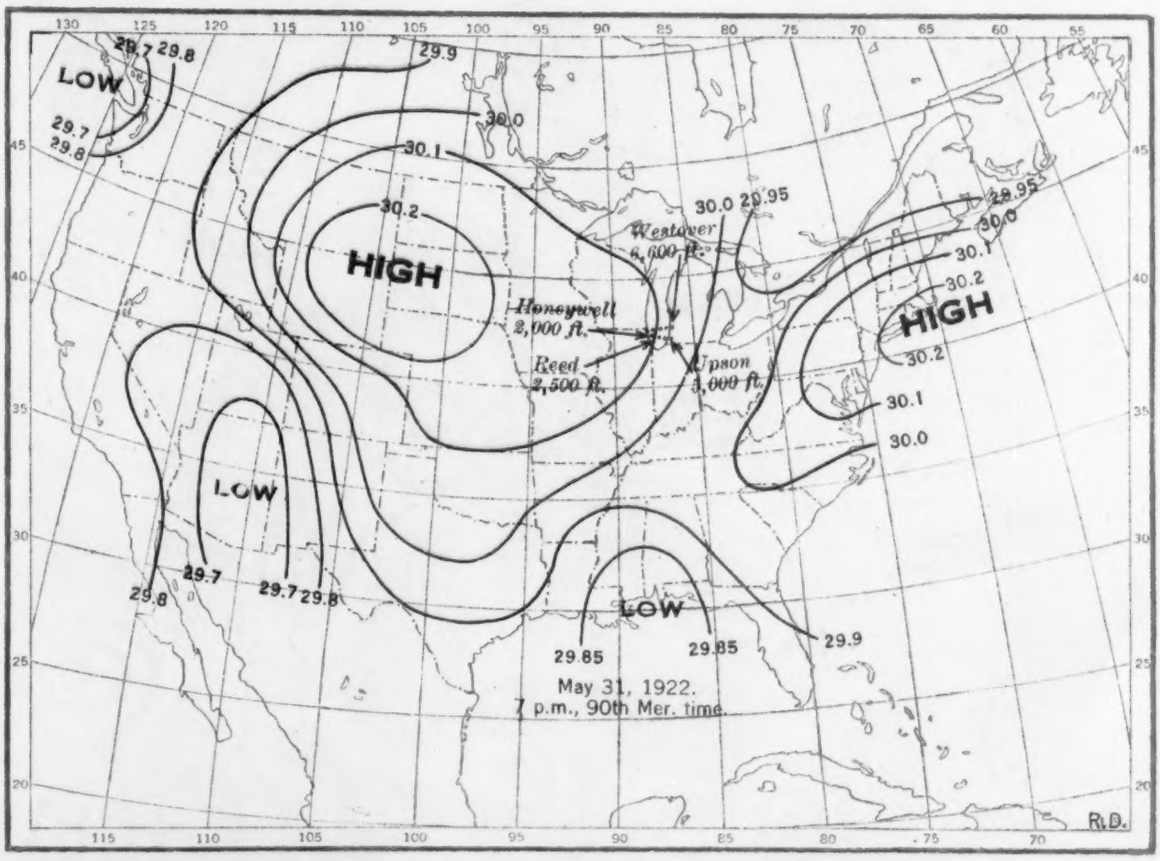
30.0
LOW
29.95
30.0
30.1
May 31, 1922.
11 a.m., 90th Mer. time.
R.D.


LOW
29.7
29.8
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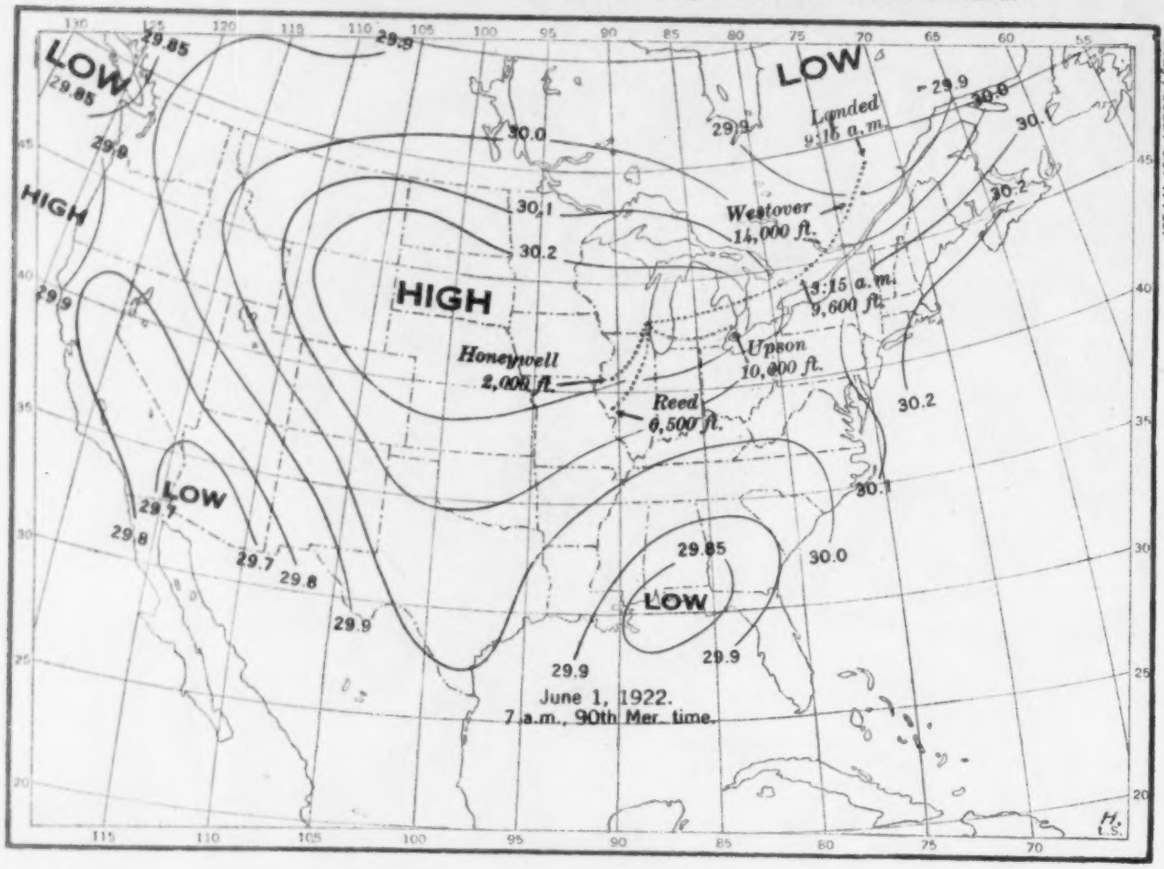
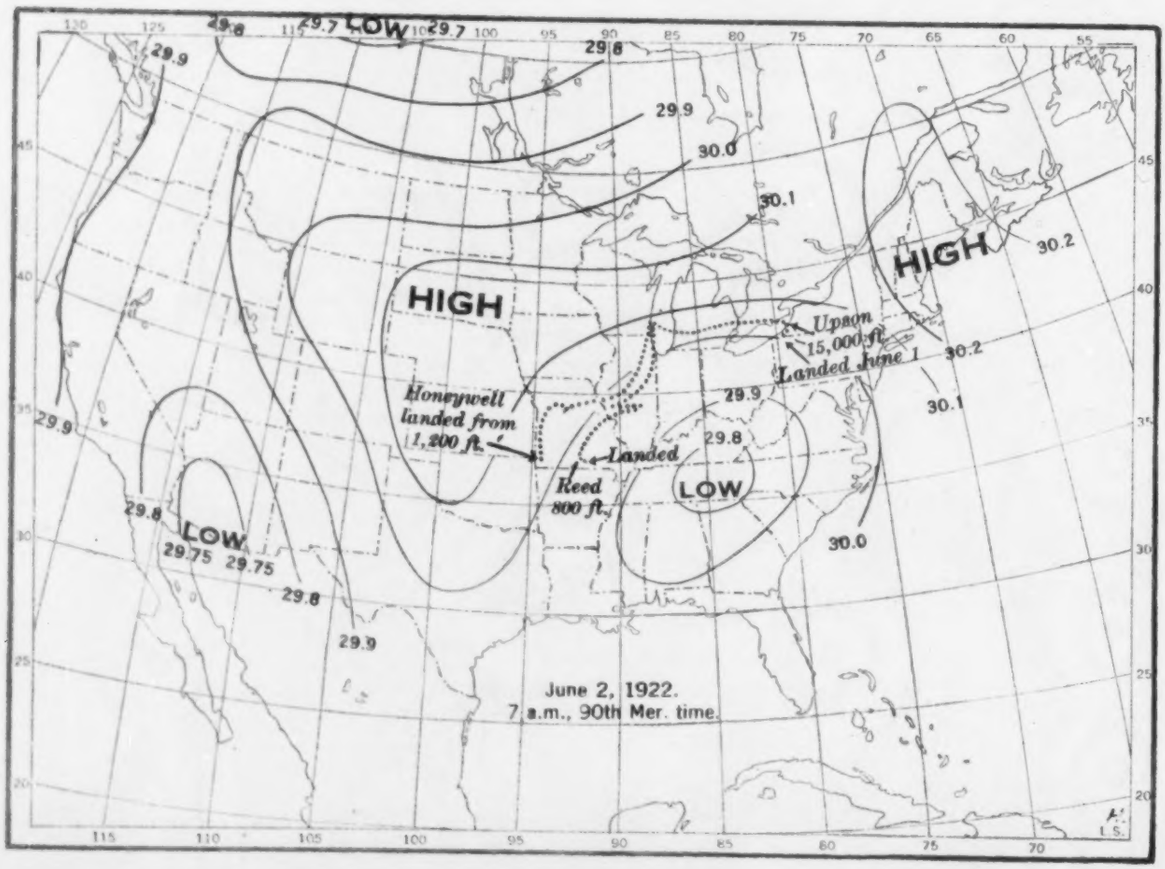
30.0
30.1
30.2
HIGH
30.0
29.95
Westover
6,600 ft.
Honeywell
2,000 ft.
Reed
2,500 ft.
Upson
3,000 ft.
29.95
30.0
30.1
30.2
HIGH
30.2
30.1
30.0
LOW
29.8
29.7
29.7
29.8
LOW
29.85
29.85
29.9
May 31, 1922.
7 p.m., 90th Mer. time.
R.D.

 Chart II.—Weather Maps during National Balloon Race.





that the balloons would have to rise about 2 miles or more in order to make good headway, at which altitude, judging by meager reports from the region east of Milwaukee, a wind of about 30 m. p. h. from about southwest might be expected. Surface and aerological reports from the Canadian Provinces to the northeast would have been invaluable.

As the barometer started to rise at Milwaukee a few hours before the race began, a deepening of the northerly winds was indicated, the significance of which to the race was that the longer the taking-off of the balloons was delayed the higher they would have to ascend and the farther they would drift toward the south before reaching the southwest winds aloft that would carry them toward the northeast. Information relative to this deepening of the northerly winds was included in the final report to the pilots.

Notwithstanding this development of conditions in the lower levels, the northeastward course was advised, as it still seemed unquestionably the preferable one for a long flight, providing the balloons took off at about the scheduled time (3 p. m.). The taking-off time was nevertheless close to a critical epoch in the march of changing weather conditions that affected the flight of the balloons, as the experience of all the pilots that attempted the northeastward course attests. Undoubtedly the opportunity for taking the northeastward course, that seemed inevitable of choice for about two days, passed soon after the last balloon took off. (See remark in this connection in report of Mr. Honeywell.)

The report of Major Westover shows that, after he was well under way toward the east from Milwaukee, he drifted at an average speed of about 55 miles per hour along the curved path to his destination in Quebec, Canada. After allowing for the decidedly increased velocity at which he traveled in the last lap of his journey, he still appears to have traveled in a decidedly stronger wind than that shown by aerological reports from stations east to Ithaca, N. Y., during the 30 hours preceding the race.

Since the aerological reports showed the winds to be of slightly variable strength and direction with altitude, and from observation to observation, it seems plausible that thin strata of winds might be encountered by the balloonists that would be of perceptibly different velocity and direction than that shown by the plots of the pilot-balloon runs. The velocities as computed are actually average velocities for successive 360 meter (1,180 feet) intervals of altitude, while Major Westover states that in the early part of his flight the depth of the air stratum in which he found the strongest wind favorable to his desired direction was barely sufficient to encompass the vertical extent of his balloon and basket. Some weight must also be given to the circumstance of the detachment of the northern extension of the low pressure trough into a marked LOW central over Lake Huron and the probable intensification of the winds aloft in accordance with the principle of such a system discussed in a previous paragraph.

The winds encountered in small steps in altitude are evidently often at variance with those shown by the smoothed curves of aerological observation plots or the orderly backing or veering of winds with altitude assumed from examination of a weather map. Quite possibly such variations are more peculiar to the more weakly defined pressure gradient systems typical of summer maps.

A succession of anomalous winds in thin layers above the cloud sheet is revealed in Major Westover's report, the first being shown by a peculiar back tracking over Milwaukee, after having first drifted a short distance to the south. Above this apparently shallow south wind he rose into a west wind, thence into a south wind again, and eventually, at about 6,600 feet, into a strong west-southwest wind, in which favorable position he remained until about nightfall. His search for this altitude is herewith narrated in his own words:

> The weather reports and maps for the day of the race, as well as the final report at 2 p. m., indicated that my preliminary judgment in this matter would be affirmed and that it would not only be possible to hurdle the low area, but that we could actually get winds in the desired direction when above the clouds. The final confirmation of this fact came about one hour before the race started, when a break in the clouds, which we happened to observe, showed a thin veil-like cloud drifting in the northeastern direction, whereas the clouds themselves were moving in a southerly direction. I made up my mind at that time I would find the particular stratum of air indicated by that veil-like cloud and would immediately attempt to cross Lake Michigan.
>
> When we finally took off our balloon traveled rapidly in a southerly direction. We were soon lost in the clouds over the southern part of Milwaukee. The higher we went the more confused we became both as to direction and speed, but we finally emerged from the clouds and found ourselves traveling toward the north at an appreciable rate of speed. We kept up this course until we had again crossed Milwaukee, when we seemed to fall into a current of air moving in an eastern direction. * * * Presently, however, due to the increased altitude gained from expansion, we found ourselves again in a current of air moving toward the north. After following this course for about 15 minutes, during which time we sighted, apparently, the balloon of Mr. Upson emerging from the clouds behind us, we determined to search especially for the northeastern current of air which we were confident existed, because we felt that the northerly course we were pursuing would take us toward Hudson Bay and would give us a rather short range for flight. Of course at this time there was nothing visible beneath us except clouds.

Making some allowance for error in estimated direction on account of the blanket of clouds beneath him, there is little doubt that Major Westover encountered a number of cross winds from north and south before he finally reached the sought-for wind to the east-northeast. In these apparently vagrant winds probably lies the explanation of the line of rains along the front of the advancing Alberta HIGH.

It is reasonable to suppose that the chilling and underrunning of the air in the deep drift from the south and southwest by the colder strata of the advancing high pressure should cause a rapid rearrangement of gradients above the line of discontinuity, particularly when the general gradients are weak, as they ordinarily are in summer. The repeated overthrow and restoration of balance is capable of explaining the stream line of air from the south, hemmed in by currents from the north. The precipitation would follow from the consequent direct cooling and convection of the air stream from the south. The records of kite observations made in the front of this Alberta HIGH show a falling off in the velocity of the north and northeast winds in and above the cloud layer, indicating a possible south or southeast wind above the limited height of the observations, into which it was manifestly impossible to raise the kites.

According to the remainder of Maj. Westover's report, he made his course to Canada after reaching his first favorable wind in three laps at successive altitudes of about 6,600 feet, 9,600 feet, and 14,000 feet. Each altitude was approximately determined beforehand by releasing a pilot balloon and observing its course, and then following it up and establishing a favorable position by control of the balloon. His first lap, made in the afternoon and evening of the first day, carried him in an east-northeasterly direction across Lower Michigan, and it was in this part of his course where he was compelled to maintain an altitude of between 6,600 feet and 6,700 feet in order to make rapid progress.

His second lap, made during the night of May 31–June 1, carried him farther east-northeast to somewhere north of Lake Ontario. Although he rose about 3,000 feet from the first to the second laps, he again found it necessary to confine himself to a shallow stratum ranging from 9,400 to 9,800 feet. Within these limits of altitude he maintained his position throughout the night. At daybreak on June 1 he rose to about 14,000 feet, where he established himself in a strong current blowing toward the northeast, which apparently greatly accelerated his movement toward the end. In this last lap he reports the same stratification of the air as regards velocity and direction that he observed in the two previous laps, for to quote his words:

> Here again (at 14,000 feet) the thickness of the particular current of air which gave us speed as well as direction was rather limited, and we found considerable difficulty in keeping ourselves within that stratum. Owing to the expansion caused by the sun we found it necessary to valve frequently.

An approximate outline of Major Westover's course is shown in Charts I and II. As nearly as can be estimated from his report, he traveled at the rate of about 50 miles per hour in the first two steps in altitude that carried him east-northeast from Milwaukee to north of Lake Ontario; thence at the rate of about 60 miles per hour at 14,000 feet altitude in a due northeasterly direction to Lake St. John, Quebec.

Of the 13 pilots who took part in the race, only four—Major Westover, Lieutenant Neeley, Mr. Upson, and Mr. Von Hoffman—attempted the northeast course aloft. Excepting Mr. Donaldson, who landed 5 miles from the starting point on account of a defective balloon, the remaining pilots chose the lower course toward the southwest.

No report is at hand from either Lieutenant Neeley or Mr. Von Hoffman, but that of Mr. Upson, who in 27 hours' flying landed at Painesville, Ohio, is probably fairly descriptive of the experiences and difficulties encountered by all three.

The following excerpts from Mr. Upson's report appear to have the most significance on the outcome of his flight:

> A brief study of the weather conditions, shown by data published before the start, led us to reject the idea of following surface currents toward the south and southwest, in favor of a bold attempt to get into currents taking us east, which we believed existed above the clouds. The result of the race proves that this was the right course, although we ourselves were not to take full advantage of it. As the wind was rather gusty at the ground, and as we wanted to get above the clouds anyway, we arranged with the ground crew so that we would be approximately six bags light when we took the air, carrying about 41 bags. The result was that we shot up fast, and without further ballast expenditure for the moment found ourselves above the clouds in the bright sunlight within 20 minutes of the time we left the field. We went almost at once to 6,000 feet altitude, but soon dropped back again to an average of about 5,000 feet, where the air seemed a little more stable.
>
> The contraction (the first night), due to the disappearance of the sun with its brilliant reflection on the clouds below us, was the greatest I have ever experienced. It was after 10 o'clock before the contraction process was fully taken care of, and it cost us altogether 22 bags, or over half of our ballast supply. * * * To get the most out of it we should have kept the balloon somewhat higher during the night, but intentionally compromised to some extent on account of our limited supply of ballast, for we wanted to make sure of being able to get through a second night. * * * For a while equilibrium was fairly good in the neighborhood of 12,000 feet, but the altitude at which we were stable steadily increased after 10 o'clock (a. m., June 1). As it turned out afterwards, the favorable wind was pushed up at about the same rate, but we did not realize it at the time. Finally, we reached about 15,000 feet altitude, but even here it soon got unstable and we started on a strong drop precipitated by more clouds forming above. * * * At the end of about an hour and a half we realized by checking our relative position in various ways that we had hardly moved at all during that time. In other words, we were practically becalmed, although we had no means over the water of realizing it immediately.
>
> The second night, which we had so carefully saved up for, was now before us, but was a liability instead of an asset. Hence we made a quick decision to land before losing any more ground, which already amounted to between 30 and 40 miles. We landed at 7 p. m. (June 1) in practically a calm about 6 miles south of Painesville, Ohio, with one bag of ballast left and practically no dispensable equipment.

Comparing the positions of Major Westover's and Mr. Upson's balloons with the series of weather maps from 11 a. m., May 31, to 7 p. m., June 1, it is apparent that the center of the Lake LOW was continually displaced to the northeast of the positions of the balloons, and that while Major Westover did not actually "hurdle" the LOW which was increasing in depth, he apparently gained on the LOW, and succeeded in keeping well within its influence. His position relative to the low-pressure center advanced from a point to the southwest at the beginning of his flight to a point about south-southeast of the center when he decided to land, indicating that he progressed northeastward faster than the LOW.

Undoubtedly the winds above the LOW were increasing in force, while in the rear of the LOW, attending the rising pressure and deepening northerly component to the winds, the favorable winds toward the northeast were dying out at progressively higher altitudes. At 3 p. m. on June 1 an aerological observation at Lansing showed a northeast wind to about 5,000 feet, backing to west at 10,000 feet. The west wind persisted in direction and increased in strength from 10 m. p. h. at 10,000 feet to 34 m. p. h. at 20,000 feet. There is therefore justification in the statement of Mr. Upson that "the altitude at which we were stable steadily increased after 10 a. m. June 1 * * * As it turned out afterwards, the favorable wind was pushed up at about the same rate * * * Finally we reached about 15,000 feet altitude, but even here it got unstable and we started on a strong drop."

Figures 1 to 5 show the pressure distribution at successive 90th meridian observation times from 11 a. m., May 31, to 7 a. m., June 2, and approximate geographic positions and altitudes of the four balloons, piloted by Westover, Upson, Reed, and Honeywell. The lines connecting the successive positions of the balloons show, for the most part, only the general directions in which they traveled, inasmuch as detailed reports of their positions, except in the report of Lieutenant Reed, were not furnished.

It is evident from the reports of Major Westover and Mr. Upson that neither rose much above 6,600 feet altitude during the afternoon of the first day. Presumably this applies also to Lieutenant Neeley and Mr. Von Hoffman.

In the technique of free-ballooning it is a handicap when preparing for a long flight to sacrifice much ballast at the start unless the pilot is assured of a swift course without frequent changes in altitude. Considerations of this nature may have deterred the pilots who chose the northeastward course from rising directly to greater altitudes. This handicap is alluded to in the following paragraph from Major Westover's report:

> The stiff ground breeze at the start of the race made it quite difficult to take off from the ground, and we had to sacrifice 16 of the 33 bags of ballast which we had in our basket for the preliminary take-off in order finally to be assured of the lift that would clear us of adjacent balloons and the grandstand of the ball park from which the start took place. I mention this fact because it had a rather vital bearing upon the speedy termination of my flight.

The decision of the pilots who took the southwestward course was undoubtedly in part for the reasons just stated and partly from considerations of probably stormy

weather conditions that would attend the northeastward movement of the Lake LOW. Skepticism of the probable weather conditions along the route would naturally lead to speculations as to the probable danger and the difficulty of reckoning position in and among the clouds in a swift course during the night.

That this caution had some justification is shown by the following references to the weather conditions experienced by Major Westover on his northeastward course: "I may add that we entered the area of clouds after we had gone about 20 miles beyond Muskegon, and that we drifted over clouds throughout the remainder of our trip," and "A quick decision was made to descend (after reaching Lake St. John), and at 11,000 feet we entered the storm area of the clouds. * * * At about 8,000 feet we ran into the rain area and were carried in a noticeably different direction from that first encountered when we entered the clouds." A decision influenced by foregoing reasons is expressed as follows by Lieutenant Reed: "High aloft at perhaps 10,000 to 15,000 feet there was a southwest gale, but it gave little assurance to the pilots of no interference by thunderstorms over Lake Huron, so that the majority preferred the lower and safer routes." Another phase to the situation, relating to the time of departure of the balloons, is brought out by Mr. Honeywell in giving his reasons for deciding on the course to the southwest: "Some time prior to taking the air I felt certain that we would not catch the NE. LOW which was fast getting away from us. * * * Major Westover was nearly three hours ahead of my time, I being last (13th) decided I was too late and fought for the next most likely distance, SW."

With all these factors to consider, the pilots were in more or less of a quandary, and the final decision as to course to pursue and speed and height of ascent naturally rested with their own judgments. From purely a meteorologist's point of view, the conviction persists, and this conviction is strengthened by a review of the weather conditions, supplemented by aerological reports from a few Canadian stations received a few weeks after the race, that a steady rise from the take-off to about 2 miles altitude would have assured a swift course toward the northeast to a distance equaling or exceeding Major Westover's record. It would probably have been necessary or expedient later to rise higher, particularly in view of keeping above the cloud layers that were deepening as the LOW developed strength toward the northeast.

An aerological observation near Toronto on the morning of June 1 shows that the deepening winds from the north had already extended that far east to an altitude of about 6,500 feet, above which the winds backed to west. At about 11,000 feet there was still a 30-mile an hour wind from the west, notwithstanding that this position relative to the weather map was by that time in a sort of col or saddle with respect to the adjacent high and low areas.

The reports of Lieutenant Reed and Mr. Honeywell show that they followed a more or less staggered course, as with changing altitude they found winds of variable directions. In the search for favorable winds and from the effects of diurnal expansion and contraction they flew at various altitudes ranging from a few hundred feet above the ground to about 6,000 feet. Lieutenant Reed records that at times midday expansion carried him to 10,000 feet. The back tracking of Lieutenant Reed's balloon on June 1 (figure 4) illustrates one of the peculiarities of the vertical arrangement of winds in the front of a HIGH. A similar situation on the same day is described as follows in the report of Mr. Honeywell:

> The sun expanding our gas carried us up to 4,000 feet (the morning of June 1), where we caught a very desirable current toward the southwest, passing over the Mississippi River south of Hannibal, maintaining a beautiful equilibrium for hours. About noon clouds began thickening beneath us, always growing thicker and denser until they finally touched the bottom of our basket at times; later, as they became higher and heavier, we were dragged through the tops of them, exceeding their speed by at least 10 miles per hour. * * * At 3 p. m. this fast stratum of air gave out and I allowed the balloon to rise, seeking another stratum above the now broken cloud banks below, through which we saw the Missouri River at Glasgow, Mo., altitude 5,000 to 6,000 feet, and course northwest. I knew then we had neared the western side of the HIGH, and immediately dropped down to between 1,200 and 1,400 feet, where we caught the surface southwest ind again, but our progress was slow.

As a matter of fact, when Mr. Honeywell found his northwest course at 5,000 to 6,000 feet he was still in the front of the HIGH, slightly east of its southern extremity. This complexity of the winds along the front edge of moderate HIGHS is entirely in accordance with records of aerological observations. Ordinarily on the eastern and southeastern edges of such HIGHS the winds will back with altitude, as, for example, from north or northwest to west; while in a position from southeast to south of the center of the HIGH, winds veering as much as 200° or more with altitude may be expected, as, for example, from about northeast through south to southwest or west. Confirmation of such a condition in the track of the balloons is given in the aerological observations taken at Scott Field, Ill. (near St. Louis), and Broken Arrow, Okla., on June 1 and 2. On June 1 the observation at Scott Field showed light north-northeast wind from the ground to 3,000 feet, thence veering and diminishing in velocity to south-southwest at about 11,000 feet. On June 2 the observations at both Scott Field and Broken Arrow showed light to moderate winds backing from north and northwest near the ground to about west at 6,000 feet, thence generally light to moderate west to southwest winds to over 15,000 feet.

By the time Lieutenant Reed and Mr. Honeywell made their landings (about 7 a. m., June 2), the high-pressure area had flattened out considerably and showed diminishing gradients in its front. It was obviously no longer possible or practicable for these two pilots to make any further headway from Milwaukee. Lieutenant Reed landed near Eminence, Mo., 440 miles from Milwaukee, and Mr. Honeywell near Joplin, Mo., 550 miles from Milwaukee, in about 42 and 39 hours, respectively.

The experiences in this race emphasize the need of furnishing advice by radio to the pilots while on their course. Consequently, the arrangements and experiments made by Mr. Upson for receiving radio bulletins of weather conditions are very interesting. He relates:

> With my experience in the International Race of last fall fresh in my mind, when I became becalmed for nine hours in the Irish Sea, I determined that the real remedy was to get up-to-date and complete reports in the air. The answer of course was radio.
>
> I took my problem to the Westinghouse Co. and the Radio Corporation of America, who very kindly offered to help in the experiment by furnishing the proper apparatus and broadcasting service in connection with the American National Balloon Race taking place from Milwaukee on May 31. The country which we proposed to traverse was divided into zones for which I eventually got support from four different broadcasting stations as follows: Westinghouse, Chicago; Westinghouse, Pittsburg; General Electric, Schenectady; Free Press, Detroit.
>
> Besides the usual weather report we made arrangements to get the special aviation bulletin issued twice daily by the Chicago station of the U. S. Weather Bureau. This was to be telegraphed to the different broadcasting stations as soon as released by the Weather Bureau. The

final operation was broadcasting by radiophone at various times and wave lengths, all prearranged. * * * For our radiophone receiver we carried a standard Westinghouse "RC" set with special lightweight batteries. * * *. We were now about a mile above Lake Michigan (evening, May 31) and could dimly see the outlines of the approaching Michigan shore. * * *. I first picked up a soprano solo—very pretty but hardly what we needed to win a balloon race. I was just putting down the receiver when the words of the announcer came clear and distinct—something about the balloon race. I gave one receiver to Andrus and we both listened in. "Four balloons in the National Race from Milwaukee are reported nearing Chicago." * * * After passing the shore line I checked our location and route, while Andrus tuned in for our weather report now about due. He quoted the words aloud as they came. (Here follows a complete synopsis of the weather map and wind forecast for the Lake region based on the 7 p. m. map of May 31).

The first weather information that we hoped to pick up was the regular daily report sent out by the Detroit News at 10.30 a. m. (June 1). Just previous to that time I conscientiously listened to several jazz pieces played on the phonograph, then, finally, came the announcement: "We will now conclude our program this morning with the reading of the daily weather report." Here I passed the receiver to Andrus, who tried to get a better adjustment, but lost connection and was not able to pick it up again. Later, at the scheduled time for our special report we also tuned up, but were unable to catch a thing. We later found the trouble to have been with the Western Union, who failed to deliver our message for about three hours after it was sent to Chicago, but we did not know then but that it was our own fault and gave up the message as lost. * * * . We had organized a successful system of getting weather reports in the air and had demonstrated to our entire satisfaction that it was not only a great help in operating a balloon but also a step forward toward greater safety.

We had been more than 15 hours over water, but felt perfectly safe throughout the whole time simply because we were still in touch with the world by radio. Our failure to get one of the messages brought home to us its importance more strongly than anything else could have done.

But the best thing I leave for the end. Major Westover, the winner of the race, also carried radio, which I procured for him before the race and which he used on the same schedule. Hence, the big idea in its first trial was not only proved sound but was a real winner as well.

From a brief résumé of the broader aspects of the meteorological conditions from May 29 to June 2, the impression is given that the dominating factors, insofar as they affected the Lake region and adjacent territory, were a succession of great drifts, first an extensive one from the southwest, and then in succession one of lesser magnitude from the west. The drift from the southwest apparently had its inception as early as May 26 or 27, in the form of a weak current from the South Atlantic, drifting inland toward the northwest, that progressively deepened, strengthened, and veered until It had attained the proportions of the extensive SW.–NE. drift observed on May 30 and 31. This drift temporarily blocked the passage of HIGHS along the northern frontier to the Lakes from the west, but gave way in its lower levels before the advance of the eastern segment of the Alberta HIGH on the afternoon of May 31.

The protrusion of the eastern segment of the Alberta HIGH into the Lake region, and the attendant formation of a definite low center over the Lakes may be construed as due to the overlapping at this point of a current from the west that was originally of Polar or northern origin, eventuating the final cycle in the development of the LOW that had its genesis in the southern portion of the deep SW.–NE. drift. Attention is brought to the striking resemblance of this construction to the life cycle of a LOW as depicted by Bjerknes and Solberg (page 80, V. Bjerknes, Dynamics of the Circular Vortex, Christiania, 1921); likewise to the other points of similarity between the assembled mental picture described in these concluding paragraphs, and the general theory of the Polar Front advanced by these Norwegian investigators.

The assumed Polar current, just referred to, had apparently backed in direction from an originally NW. to SE. tongue of cooler air, and was now (June 1–2) evidenced by aerological observations as a drift aloft from the west, that bent toward the northeast where it merged with the SW.–NE. drift over the Atlantic States. This drift from the west, or remnant of the assumed Polar current, was dying out, with which fact may be connoted the flattening out of the HIGH over the Central States, and the eventual becalming of all the pilots who were still in the air by the evening of June 1, 1922.

BUMPY FLYING CONDITIONS ALONG THE ATLANTIC COAST.[1]

By A. W. PARKES.

The writer was a radio observer on naval seaplanes and flew the Atlantic coast from Cape Cod to New Orleans and over many of the West Indian islands.

As a general rule, under similar geographical conditions, the hotter the climate the greater the bumpiness in the air. The worst places experienced were the Hudson River at a low altitude (200 feet or lower), the Florida Keys, and the bay at Guantanamo, Cuba.

The probable explanation of the bumps in the Hudson is that the west wind passing over the Palisades tends to form an eddy on a horizontal axis, going down over the Hudson, flowing westward near the water, and rising near the sides of the Palisades as is roughly shown in the accompanying diagram.

A seaplane going up the river often experiences a drop of 15 to 50 feet very abruptly, and sometimes only one wing goes down or just the nose or just the tail. Under these conditions with a large plane both pilots have all they can do to manage the controls.

The case over the Florida Keys is quite different, though the effect is the same or worse. On nearly every day there seem to be strong convectional currents rising over these small islands, which are heated to a much greater heat by day than the water, thus causing that less dense air to rise and, consequently, the colder to descend to fill its place. "Bumps" are the consequences.

I have heard pilots say "I'll bet I could tell when we were over Guantanamo Bay if I were blindfolded or if it were pitch dark, it's so bumpy in that vicinity." Guantanamo Bay lies on the southern part of Cuba, and there are mountains about two-thirds of the way around it. During the months of February and March, while the writer was there, the weather rotated daily like clockwork—a very calm morning, followed by a breeze at 2 p. m., becoming strong at about 4 to 5 p. m. every evening, with almost no exception, during those two months. But even though there was little surface wind in the morning, this excessive bumpiness occurred throughout the day, although it was worse in the afternoon. This necessitated as much flying as possible to be done in the early morning. The reason for the bumpiness seems to be a combination of the two reasons given previously, i. e., the heated land and the deflections due to the mountains. A thing of interest is the fact that when flying directly over the funnel of a battleship the effect can be felt for at least 200 feet up.

It may also be interesting to note that we could feel the concussion on our plane from a broadside of a battleship when we were 4,000 feet above the ship.

[1] Submitted in reply to the request in the MO. WEATHER REV., Aug., 1919, p. 532, for notes on flying and the weather.

Without any doubt, fog and rain are the two greatest enemies of the aviator. The worse of these is the fog, however. Rain to a pilot feels exactly as one's foot feels when "gone to sleep" except that it is about 10 times as bad. It feels as though someone had a mass of needles pressing them onto the hands and face, to say nothing of the extreme coldness of the result. Fog, or cloud, however, is very different. The order was given for a squadron of seaplanes to leave Hampton Roads, Va., to come north to greet the *George Washington* when she came back with President Wilson from France. On leaving Cape May, N. J., there was a cloud extending down to about 250 or 300 feet altitude, so the order was given to ascend above the clouds where flying was very simple by compass. Being seaplanes, there was a great fear that something would go wrong and that the squadron would be over land rather than water if forced to land suddenly, which would necessarily cause a total wreck. The commanding officer of the flagplane sent us all a radio message, "Remain aloft, am going down to ascertain weather conditions." We all received the message and ok'd it, then waited for the result. The flagplane dove into the clouds—out of sight—and in about 15 minutes another message came, "All clear 200 feet, descend." Immediately all the remaining planes dove into the clouds. We did not see the other planes until we had arrived at Rockaway Beach hours later. We were at that time in the vicinity of Atlantic City. We managed to fly along the surface of the water, barely able to see 100 yards ahead, contrary to the commanding officer's report, and having the constant fear of an approaching ship whose mast we might hit. We finally spied Fire Island Light, stopped, asked directions, and took off again. Soon the fog came in still worse, and many a time the wings would be at an angle of 45 to 60 degrees to the horizontal, which is great for a large, 5-ton seaplane. Both port and starboard pilots together worked as fast as they could, to keep her righted, the level-bulb being of no use because it did not show a horizontal owing to the turning of the seaplane. The climax came near Long Beach, where, coming out of the fog over water, we barely missed a house, rose, and turned, only to skim the top of a huge elm tree. Directly ahead was a little creek, into which our pilot headed the machine. It was just big enough to clear the banks. We put out our anchor immediately and waited for the fog to clear. At 11 o'clock it had lifted, but it was raining instead. As rain was merely disagreeable and fairly bad for the propellers, we made our way in the rain to Rockaway Beach. After landing, anchoring, covering up the motors, etc., our commanding officer came down and gave us the order to go out and meet the *George Washington*. All wet and cold, we "took-off" again and met the ship, the rain driving in our faces all the while.

These are but a few incidents which could be paralleled by many an aviator, especially by one who has flown in the South or over land and water.

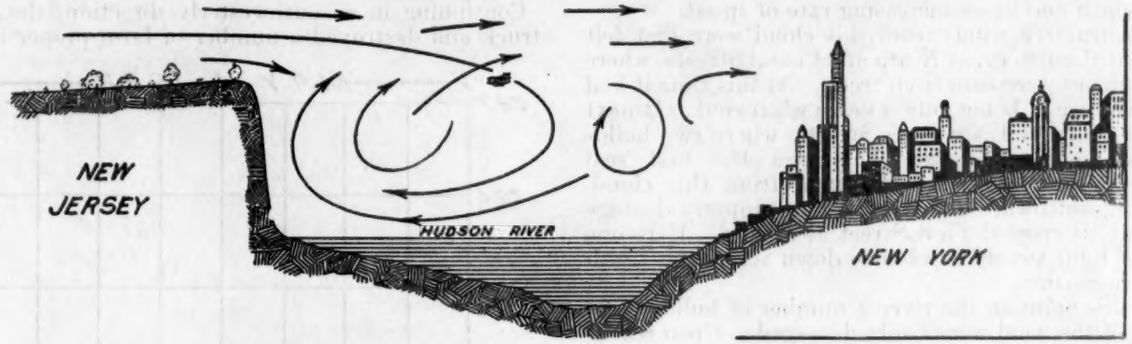


FIG. 1.—Showing the formation of a horizontal eddy over the Hudson River near New York City.

THE AUSTIN TORNADO OF MAY 4, 1922.

By FRED MORRIS, Cooperative Observer.

[University of Texas, Austin, Tex., June 14, 1922.]

EASTERN CLOUD.

The morning of May 4 was sultry, with clear skies and a very light southeast breeze. By 11 o'clock small cumulus clouds had begun to form. These clouds remained stationary, or practically so; if they had any movement it was so slight that their direction could not be noted.

By noon the cumulus clouds to the northeast had begun to develop into a cumulo-nimbus. There was nothing unusual in the appearance of the cloud at this time. It was just a "thunderhead" from which a shower might be expected later in the afternoon. It remained practically stationary, slowly increasing in size until about 2:30 p. m., when it began to spread southward.

At about 3:15 p. m., what appeared to be cumulus clouds at a very high altitude and moving rapidly were observed coming in from the southwest. Below these and coming in from a point somewhat east of south could be seen ragged patches of dark cloud. The scud floating rather low and at a high velocity was coming in from all directions south of a line drawn east and west through the university. These clouds formed rapidly into a huge ugly looking mass with a very low, densely black base and high pink summit. This new cloud was building up at a point somewhat east of the original cloud and about half way between it and town. The development of this second cloud was very rapid; also, it seemed to be moving southward as it developed. At about 3:45 p. m. the first sharp peal of thunder was heard. Up to this time the sky below the bases of these clouds had remained practically clear, but now began to show dark streaks, indicating that precipitation had begun.

By 3:50 p. m. a definite movement southward of both clouds was in progress. The eastern portion of the original cloud had become obscured by the second cloud

and lightning was more frequent. It had grown dark enough to make artificial lighting necessary in the buildings.

As the second cloud moved southward there was a visible lowering of the central portion of its base. There was a violent churning action about this protuberance, and the whole base of the cloud seemed badly agitated. No true tornado funnel had as yet developed in connection with this cloud, but the projection was lowering and the agitation becoming more violent as it moved southward.

From this time forward, developments were rapid. The whole storm was moving in a direction about 30° west of south and at an increasing rate of speed.

The destructive winds from this cloud were first felt at the State Cemetery, at Ninth and Comal Streets, where some branches were torn from trees. At this time it had the appearance of being only a fierce whirlwind. It next struck at Sixth and Navasota Streets, where two buildings were badly damaged. This was the first real property damage done by the wind from this cloud. Continuing southward and doing minor property damage on its way, it crossed First Street at Waller. Here one of the tall light towers was blown down across the Tenth Ward Fire Station.

From this point to the river a number of buildings in the path of the wind were badly damaged. Upon reaching the swollen river the true character of the cloud was outlined for the first time. An enormous volume of spray was lifted and whirled high into the air. It seemed as though a long white column of smoke had suddenly flashed into existence, and a few moments later as suddenly disappeared.

After crossing the river the whirl moved up the high south bank into Travis Heights, where a number of fine homes were damaged or destroyed. (See Fig. 3.)

From this point on the funnel-shaped cloud could be clearly seen. Viewed from the high downtown buildings it had the appearance of being a whirling, churning mass of clouds. Observers could clearly see the materials of the buildings thrown high into the air as building after building was struck. At this point the path was about 50 yards wide.

Continuing in a southerly direction, the wind next struck at St. Edward's College, where the dormitory, gymnasium, and power plant were destroyed. (See Figs. 5, 6, 7.)

Men working at Penn Field who were watching the approach of the storm said, "It looked like a funnel-shaped mass of cloud and dust, churning and whirling and carrying things high into the air and then scattering them in all directions." At the center of this whirling mass was a small black core about as big around as a man's body (viewed from Penn Field about one-half mile distant), moving along in a zig-zag path, swinging very much like the trunk of an elephant. As this black core moved forward everything seemed to rush in to meet it. Large trees were torn up by their roots and drawn in, tops first; buildings of all sizes just seemed to go to pieces, and the materials, especially the roofs, sail in toward this central core, where they were torn to pieces and carried high into the air. Some of this material was thrown out at a height of 100 feet or more, while some of it disappeared entirely.

The storm next struck Penn Field—the Woodward Manufacturing Co.'s plant—where the greatest property damage in the storm's path occurred. (Fig. 4.)

Immediately after striking Penn Field the cloud turned sharply to the southwest and passed through the St. Elmo neighborhood, where the Heartkoff Dairy plant, the Harper home, and the Holden residence were struck in succession and completely swept away. Other buildings in the neighborhood were damaged. (Fig. 2.) The width of the storm's path had gradually increased up to this point, and was about 225 yards wide here. Trees blown down along the western edge of the path were lying to the south, while those on the east side were lying to the north, showing the wind to have had a counter-clockwise direction, considering the clock lying face up on the ground.

Continuing in a southwesterly direction, the tornado struck and destroyed a number of farm properties in its path. The next important destruction was in the neighborhood of Davis Hill, about half way between Manchaca and Oak Hill. The tornado seems to have been approaching Davis Hill along a straight line. At the foot of this hill some small houses were destroyed. The funnel then turned abruptly to the west and completely swept away the Bargsley home, killing six persons. A student at St. Edward's college was also killed, and other fatalities increase the total number of deaths to 12. Fifty persons were injured.

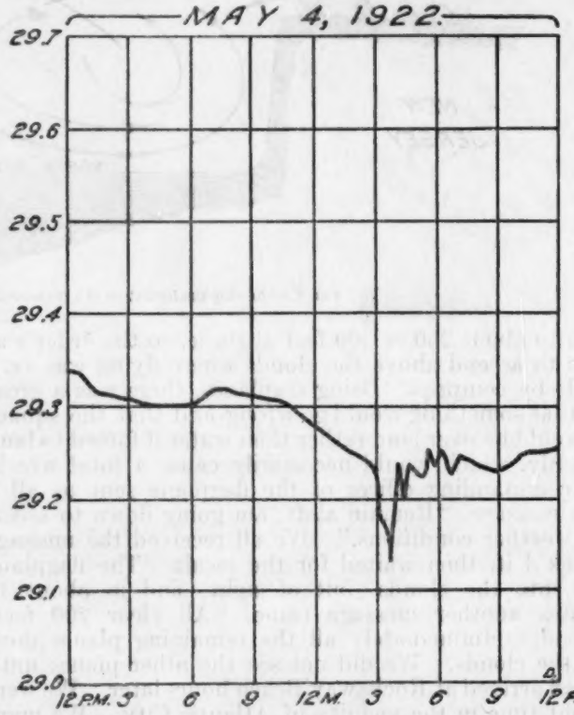


FIG. 12.—Trace of the barograph at the University of Texas on May 4, 1922, showing the disturbance at the time of the occurrence of tornadoes in that vicinity.

From this point on slight damage was done to farm property, as the funnel continued in a westerly direction and finally lifted from the ground. It is interesting to note that when last seen this funnel was lying in an almost horizontal position, and resembled very closely the funnel which swept through the western part of town.[1]

The trace of the University of Texas barograph is shown in Figure 12.

[1] Cf. MO. WEATHER REV., 45: 238; 47: 448–449.

(To face p. 252.)

FIG. 1.—The Austin tornado of May 4, 1922 (western cloud). This photograph was taken at 3:48 p. m., from the Littlefield Building, when the cloud was about 3 miles northwest of the camera. The funnel had just risen from the Negro Blind Institute when Mr. T. B. Kellum took the picture. Negative owned by the Gazley Co., 204 W. Sixth Street, Austin, Tex. (Courtesy Austin Chamber of Commerce.)

FIG. 2.—Site of the Harper home at St. Elmo. The house, which was destroyed by the eastern cloud formerly stood within the rectangle formed by the four oaks.

FIG. 3.—Home in Travis Heights damaged by the eastern cloud.

FIG. 4.—Water tower at Penn Field destroyed by the eastern cloud.

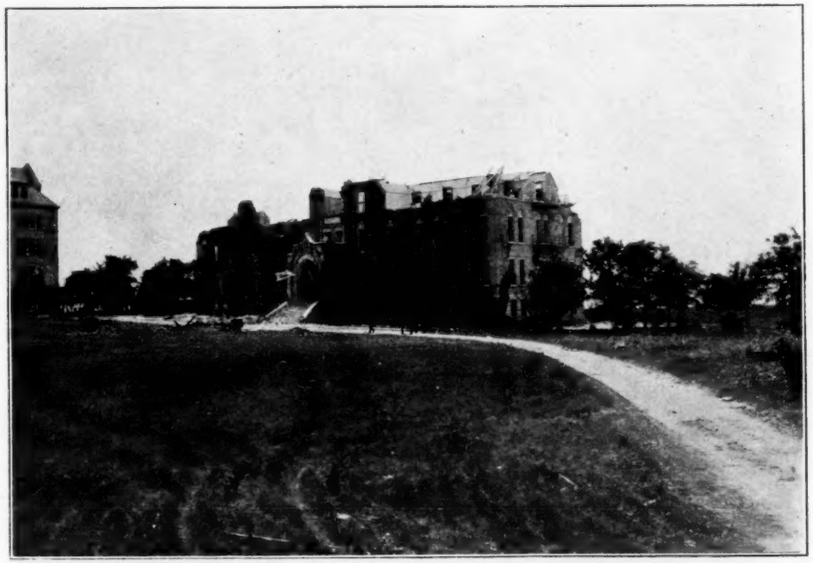


FIG. 5.—Front view of Holy Cross Hall, St. Edwards College, damaged by the eastern cloud.

FIG. 6.—Rear view of Holy Cross Hall, St. Edwards College.

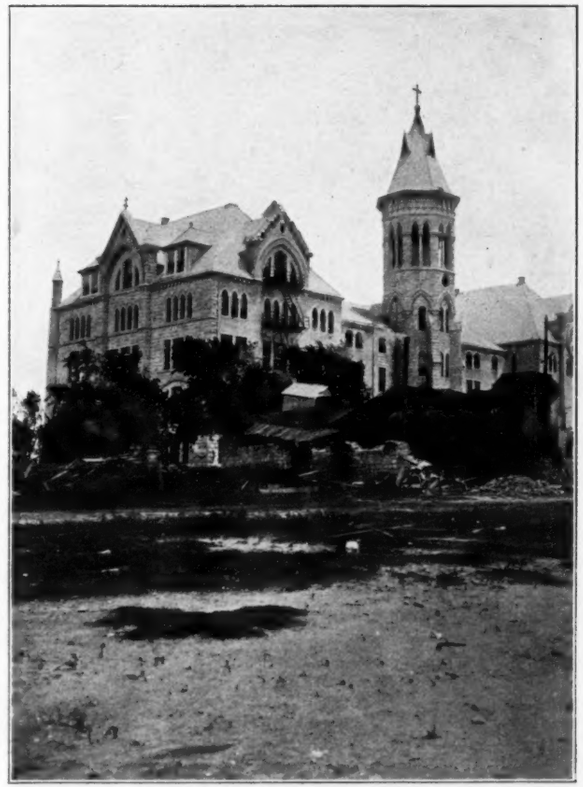


FIG. 7.—The power plant, St. Edwards College.

(To face p. 252.)

FIG. 8.—Western cloud of the Austin tornado. (Copyright, Photographic Laboratory, University of Texas.)

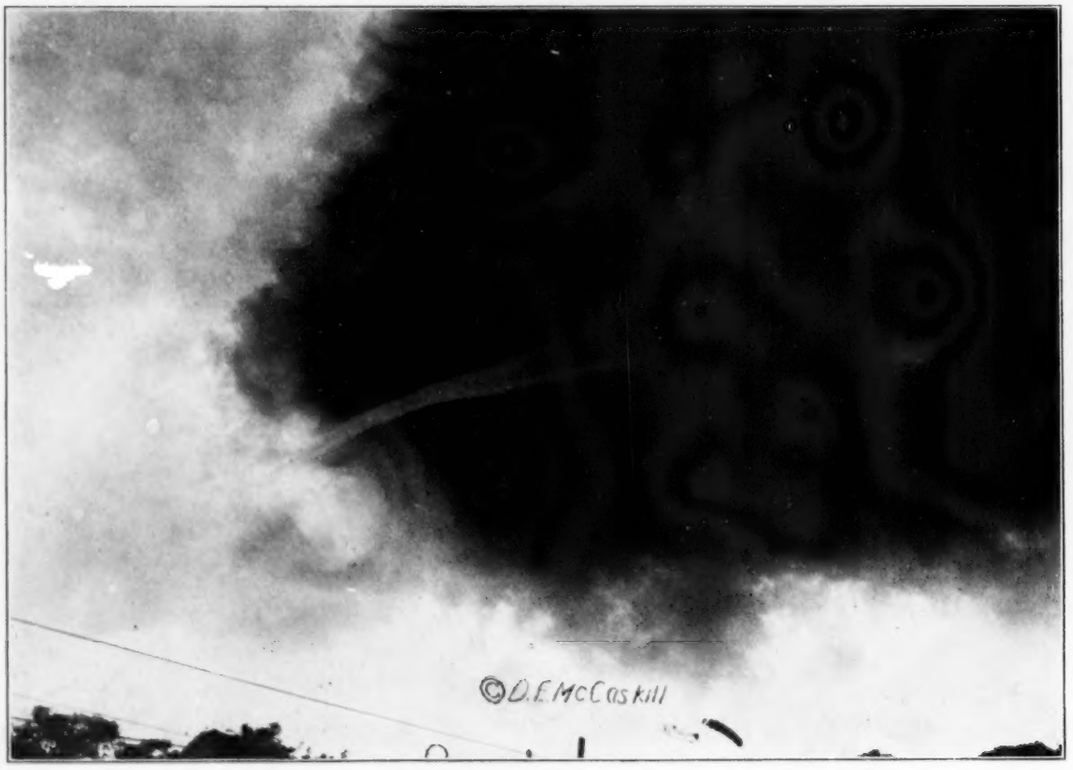


FIG. 9.—Western cloud of the Austin tornado. (Copyright, Photographic Laboratory, University of Texas.)

FIG. 10.—Western cloud of the Austin tornado. (Copyright, Photographic Labaratory, University of Texas.)

FIG. 11.—Austin tornado (western cloud). This photograph was taken by Mr. A. D. Boone, at 4:12 p. m., May 4, 1922, when the cloud was about 2 miles west of the camera. (Courtesy Austin Chamber of Commerce.)

WESTERN CLOUD.

While the eastern tornado was by far the larger and more destructive, it was not seen by nearly so many people as was the western cloud. (Figs. 1, 8, 9–11.) It was this spectacular western funnel which practically every one was watching while the eastern funnel formed and cut its destructive path through the southwestern portion of the county.

The wind from this cloud was first felt in contact with the ground at a point about 6 miles northwest of town, where some farm buildings were damaged. Its next important destruction was about 3 miles farther south, at the State school for the negro deaf, dumb, and blind. At this institution the industrial building, the laundry building, and a dormitory were destroyed. Moving in a southwestern direction and along a line practically parallel to the path of the eastern cloud, it next struck at Deep Eddy on the river's bank. At this point considerable property damage was done and two persons injured. Lifting a large volume of spray high into the air as it went, the whirl crossed the river, cut a path about 25 yards wide through the timbered hills, and eventually disappeared to the southwest. The path of this funnel while in contact with the ground was about 3 miles to the west of, and practically parallel to, the eastern funnel.

SOME OBSERVATIONS MADE ON THE ORIGIN, GROWTH, AND DISAPPEARANCE OF THE TORNADO WHICH PASSED WEST OF AUSTIN MAY 4, 1922.

By PAUL T. SEASHORE.

[University of Texas, June 14, 1922.]

While seated by a north window in Breckenridge Hall at the University of Texas on the afternoon of May 4 I became aware, due to the rumbling of thunder, of an accumulation of clouds in the north and northeast. On account of the heat of the early afternoon and of the knowledge that we were in an area of low pressure I thought it perhaps advisable to watch these clouds for symptoms of tornadic disturbances.

The clouds approached quite rapidly and seemed to be traveling in a southerly direction, perhaps slightly west of south. The approaching clouds were scarcely 5 miles away when I first became aware of the tornadic formative disturbance. In a position nearly due north a ragged edge, or that part which appears to an observer as being the bottom of the cloud had in one place dipped lower and had assumed the shape of a V with a slender threadlike appendage swinging from the bottom. This smokelike wisp was continually being drawn up into the larger V-shaped body, staying there for the space of a second or two, and then trailing down to the earth again, swinging to the right and to the left. This phenomenon was continued for possibly two or three minutes, and then the V-shaped body with its appendage disappeared.

After being absent for about the same length of time that it had been present, the body reappeared as before, only it had grown larger and had shifted from north to a position a few degrees west of north. Directly above this minature tornado small fragments of clouds were flying here and there with an irregular motion, confined, it seemed, however, to a certain area horizontally but not vertically. From this irregular boiling there gradually grew a regular movement, which was counterclockwise and assumed the shape of a narrow, slightly tapering cone inclined at an angle of about 30° with the horizontal. The small V-shaped body was drawn up into the larger cone, but the threadlike wisp of the former remained and was seen to grow larger, attach itself to the tip of the larger cone, and extend vertically to the ground. It remained on the ground for a few seconds and then drew up to a position about midway between the cone and the ground. The tornado at this stage was approximately north 25° west from my position. As the rapidly whirling gray cone passed to the west it assumed a more vertical position and appeared to grow slightly larger. Fragments of ragged clouds could be seen drawn into its vortex. After the cone had passed to the southwest of my point of observation it became funnel-shaped and again seemed to dip toward the earth. It now gradually broadened out, became bell-shaped and disappeared in a heavy rain.

This tornado was followed by a cloud having a bluish green color. The whirling cone itself had a grayish color until it became obliterated by the rain.

TORNADO FREQUENCY IN KANSAS.

By S. P. PETERSON, Meteorologist.

[Weather Bureau, Wichita, Kans., May 18, 1922.]

The following table has been compiled from the readily available records of tornadoes in Kansas so that there may be a clearer conception of the frequency of occurrence of tornadoes in that State. The records upon which the table is based are compiled from Mr. S. D. Flora's article on "Tornadoes in Kansas," published in the MONTHLY WEATHER REVIEW of December, 1915, and from the records of tornadoes found in the *Monthly Climatological Data* for Kansas for the years 1916 to 1921, inclusive, published by the Topeka Weather Bureau office, the *Climatological Data* having been carefully scanned for all records of tornadoes contained during that period. The total, apparently quite complete, records of tornadoes cover a period of 30 years—from 1874 to 1887, 1889 to 1896, and 1914 to 1921, inclusive. When tabulated we get the following results, showing the total number of tornadoes that have occurred in the various months during the period of record, from which is computed the average monthly frequency and the average number of tornadoes that may be expected to occur in Kansas per year.

TABLE 1.—*Tornado frequency in Kansas, 30 years' record (by months).*

	Total.	Average monthly frequency.
January	0	0.00
February	1	.03
March	19	.63
April	49	1.63
May	84	2.80
June	60	2.00
July	18	.60
August	16	.53
September	10	.33
October	5	.17
November	3	.10
December	0	.00
Total for 30 years	265	
Average per year	8.8	8.8

From this table we find that no tornadoes are likely to occur in Kansas in January or December, that in only one year out of 30 is a tornado likely to occur in February, that the monthly frequency increases to three in each May, and that but one tornado occurs in each 10 years in November. The average annual frequency of tornadoes for the State is 8.8. However, since the area of destruction of a single tornado rarely exceeds 25 square miles,[1] and many cover a much smaller area, while the total area of Kansas is more than 80,000 square miles, it follows that, on the average, no given place in the State will experience a tornado oftener than once in about 600 years.

[1] Abbe, Cleveland: Tornardo frequency per unit area. MONTHLY WEATHER REVIEW June, 1897, p. 250.

KASSNER ON LEGAL METEOROLOGY.

By C. LEROY MEISINGER.

[Weather Bureau, Washington, D. C., June 21, 1922.]

The lawyer, perhaps more than other professionals, is often forced far afield in the prosecution of his profession. He is not infrequently obliged to interest himself, sometimes intensively, sometimes superficially, in subjects quite antipodal to the ordinary technique of the legalist. The sciences have often had their day in court. Astronomy, chemistry, medicine, engineering, meteorology, and others—all have contributed their expert witnesses. But one difficulty which confronts the lawyer upon examining the expert witness is his own lack of intimate familiarity with the science or data. Not knowing how the data were collected and by whom, not appreciating the full significance of the evidence he is bringing out, the attorney may fail to ask the proper questions or fail to ask them in the proper way. It is for the lawyer, the judge, the administrator, the business man, the layman, and, indeed, for all who may be confronted with the use of meteorological data in legal proceedings and in daily life that Doctor C. Kassner, of the Prussian Meteorological Institute, has written his *Gerichtliche und Verwaltungs-Meteorologie*.[1]

In spite of the frequent use of meteorological data in this way, Doctor Kassner's thorough and interesting book, based upon his 30 years of experience, is the first of its kind in the world's meteorological literature. The work is divided into three major divisions—the first dealing with the weather and its observation, the second with questioning concerning the weather, and the third with the giving of information concerning the weather.

The first section is a general compendium of information concerning instruments, units, stations of various orders and their equipment, principal weather services of the world and their addresses. This section enables one unfamiliar with meteorological organizations to get a fair idea in a short time of the character and scope of the work they perform and the data they collect.

The second major section is devoted largely to that phase of the use of meteorological evidence mentioned in the opening paragraph of this review, namely, the intelligent questioning of the expert. Questioners are divided by Doctor Kassner into five groups: (1) Technicians; (2) military officials; (3) attorneys; (4) magistrates; and (5) private individuals.

The author believes that in many instances the German proverb *Wie man in den Wald ruft, schallt's wieder heraus*, is quite applicable to the questions that often are asked and the replies that must be given, for "as one asks, so shall he be answered." He points out the unnecessary circumlocutions often employed in the statement of the question and urges brief and pointed statements. He deplores the lack of proper use of ordinary terms, incorrect spelling (for example, metrological, meteological, metriological, etc.), and loose ideas concerning the application of the data. He says, finally, that a properly-put question should contain (1) the date, accurately stated to as small time units as possible; (2) the place, as specifically as possible; (3) the weather element involved, clearly stated, as, for example, rain, snow, or hail rather than precipitation; (4) the circumstance involving the data, such as spoiled meat, heat stroke, or accident due to glaze; and (5) the willingness to pay for the information.

The third section of the book is of greatest popular interest and perhaps of greatest value, for it contains running comment, queries, and replies for 438 examples, selected from actual experience, dealing with the various meteorological elements. Some of these possess a touch of humor, some illustrate how a trivial meteorological circumstance may be the turning point of an important case, and all show the manifold ramifications of weather influences in the daily life of man. Some examples follow:

1. An automobile collided with a milk wagon which carried no lights at 9.45 p. m. The driver of the wagon maintained that it was still so light that no lights were necessary.

Reply: Twilight ended at 9 o'clock; the moon was not shining; there were a few clouds. A burning lantern was, therefore, quite necessary.

2. A woman was arrested by the police in a market for having sold spoiled goose meat. She maintained that excessive heat was responsible.

Reply: Highest temperature was only 20° C. (68° F.).

3. In a railroad shipment of filled flasks a part of the flasks were found cracked and empty. The railroad company maintained that it was the result of severe frost.

Reply: No; for on only one day was light frost (−2° C.) (28° F.).

4. A man in running from a large dog fell and broke his leg. The owner of the dog maintained that rain had made the sidewalk so smooth that the man had slipped and thus injured himself.

Reply: No rain, but clear sky instead.

5. Lighning struck a tavern and it burned. In opposition to the guests, whose effects were destroyed, the landlord maintained the misfortune was an "act of God."

Reply: There was a thunderstorm.[2]

These cases have been selected at random and can presume to do no more than suggest the field covered by the 438 examples. Nor can any idea of the running discussion offered by the author be given, for he constantly points out the best statements and the outcome of the trials. He shows throughout how the reply is limited by the query and how the meteorologist must confine himself strictly to the meteorological aspects of the question, even when there are ramifications closely allied to the meteorological phase, as in the last example given above. A large section is devoted to cases, always frequent where meteorological forces are concerned, involving the "act of God" (*Höhere Gewalt*).

[1] *Gerichtliche und Verwaltungs-Meteorologie, Das Wetter in der Rechtsprechung für Gerichte und Rechtsanwälte, Verwaltungen, Magistrate und Hausbesitzer, Berufsgenossenschaften und Versicherungsgesellschaften, für Gewerbe, Handel und Technik. Mit 438 Beispielen aus der Praxis.* Berlin and Leipzig. Vereinig. wiss. Verleger, 1921. 8°; 208 pages.

[2] It was maintained in the trial, however, that such defense was not valid since the inn was not protected by lightning rods. Had the inn been so protected, it was held, the owner could properly have defended himself upon the grounds of an "act of God."

Doctor Kassner's book suggests the need for a similar work in English, based upon the wealth of experience that is surely to be found among meteorological workers in English-speaking countries. It is a valuable contribution to the literature of meteorology in a field untouched by others. It should be read by professionals and laymen whose interests carry them into legal and administrative activities likely to employ meteorological data.

DRY SEASON, 1921–22, IN THE CANAL ZONE.

By R. Z. FITZPATRICK, Chief Hydrographer.

The 1921–22 dry season began about January 7 and ended about May 4, 1922. It was of shorter duration than those of 1919–20 and 1911–12, which were, respectively, the driest and next to the driest since the American occupation of the Canal Zone.

Comparative rainfall figures for these three periods are given below.

Rainfall, inches.

Stations.	1921–22, Jan. 7 to May 4, inclusive.	1919–20, Dec. 16 to May 13, inclusive.	1911–12, Dec. 1 to May 7, inclusive.
Porto Bello	13.92	10.18	5.74
Colon	5.39	5.26	6.37
Gatun	7.41	3.37	10.30
Mount Lirio	4.75	2.41	9.29
Gamboa	3.56	2.52	3.03
Alhajuela	1.22	1.78	1.02
Vigia	1.22	1.51	1.60
Culebra	2.68	2.79	3.85
Empire	1.69	3.02	3.20
Pedro Miguel	5.64	6.15	6.29
Balboa Heights	3.69	4.46	4.76
Total	51.17	43.43	55.45

The Chagres River discharge was 48 per cent above the 21-year four-month dry season average, or 1,893 c. f. s. against a mean of 1,279 c. f. s. The minimum discharge of the Chagres for the four months was 555 c. f. s. on April 25; the maximum discharge for the same period was 29,100 c. f. s. in the freshet of January 2, during which, in order to control Gatun Lake, it was necessary to open seven spillway gates with a maximum momentary discharge of 92,778 c. f. s., the highest momentary spilling on record.

Gatun Lake fell to elevation 84.47 feet during the four-month period and continued to recede to elevation 84.27 feet on May 7, from which date the recovery of storage was begun. A loss in storage of 11.65 billion cubic feet occurred during the dry season, compared with 22.8 billion cubic feet for last year and 24 billion cubic feet for 1920. There being no necessity for conservation of water, as was necessary in 1920, little if any effort toward this end was made. Evaporation from the lake's surface was 24.59 inches, approximately the entire storage depletion. The water necessary for useful losses was considerably less during the past dry season than that of 1921.

The following data show the net inflow into Gatun Lake for the dry-season months since the formation of the lake:

Net yield in C. F. S.[1]

	Dry seasons of record.											Average for month.
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	
Dec.[2]	2,690	5,335	4,307	7,010	7,673	4,986	9,218	2,158	4,939	3,698	7,649	5,424
Jan.	400	2,583	1,739	2,570	1,863	1,111	3,023	1,541	769	1,216	8,641	2,314
Feb.	271	1,298	744	4,207	1,320	139	431	73	−287	951	1,482	966
Mar.	−392	678	167	823	698	−182	36	−50	−385	−121	190	133
Apr.	−363	567	308	5,400	1,076	447	1,119	3,250	−706	244	210	1,050
May	2,771	4,992	3,219	6,111	4,063	4,635	7,964	4,352	583	2,109	.....	4,080

[1] Net yield is the total yield minus the evaporation on Gatun Lake.
[2] Decembers are of previous year; i. e., December, 1911, is in 1912 dry-season.

Figure 1, page 256, accompanying this report, gives the hydrology of Gatun Lake for the four-month dry season, January 1 to April 30, 1922.

NOTES, ABSTRACTS, AND REVIEWS.

WEEKLY WEATHER AND CROP REPORTS.

Beginning with the first week of July the system of collecting information respecting the effect of weather on crops hitherto in vogue will be broadened to include the several first and second class Weather Bureau stations in each State. These stations will report direct to the section center. The Section Director will continue to summarize all of the data received and telegraph the results to the Central Office in Washington Tuesday mornings throughout the year. The release of the information to the public has been set for 10 a. m. Wednesday mornings.

PHOTOGRAPHIC SPECTRUM OF THE AURORA OF MAY 13–15, 1921, AND LABORATORY STUDIES IN CONNECTION WITH IT.

By LORD RAYLEIGH.

[Abstracted from *Proceedings of the Royal Society*, A101, 114–124, 1922.]

Exceptionally fine photographs of the auroral spectrum obtained by Rayleigh during the brilliant display of May 13–15, 1921, show quite definitely that the chief auroral line is quite out of coincidence with the krypton line, the whole spectrum being accounted for by the auroral line, of unknown origin, and the negative bands of nitrogen, the latter predominating. An attempt was made to reproduce the nitrogen bands as they appear in the aurora by a discharge tube in the laboratory, but without complete success. So far as it goes, however, the evidence gathered would favor the idea, which has sometimes been advocated, that rays of *atomic* nature, not electrons, from the sun, give rise to the aurora.

The photographs clearly confirm all previous evidence that the lines of those elements ordinarily supposed to constitute the high atmosphere are not present. If hydrogen is really present, a formidable difficulty is therefore encountered, for according to all laboratory experience even a trace of hydrogen asserts itself in the spectrum of any kind of electric discharge through air under any conditions of pressure. However, on the suggested hypothesis of *atomic* rays, it is also difficult, in the light of the evidence afforded by specially devised experiments, to explain the absence of helium and nitrogen *lines*. It would seem best not to lose sight of the possibility that the mode of excitation may be something entirely different from either electronic or atomic bombardment.—*E. W. W.*

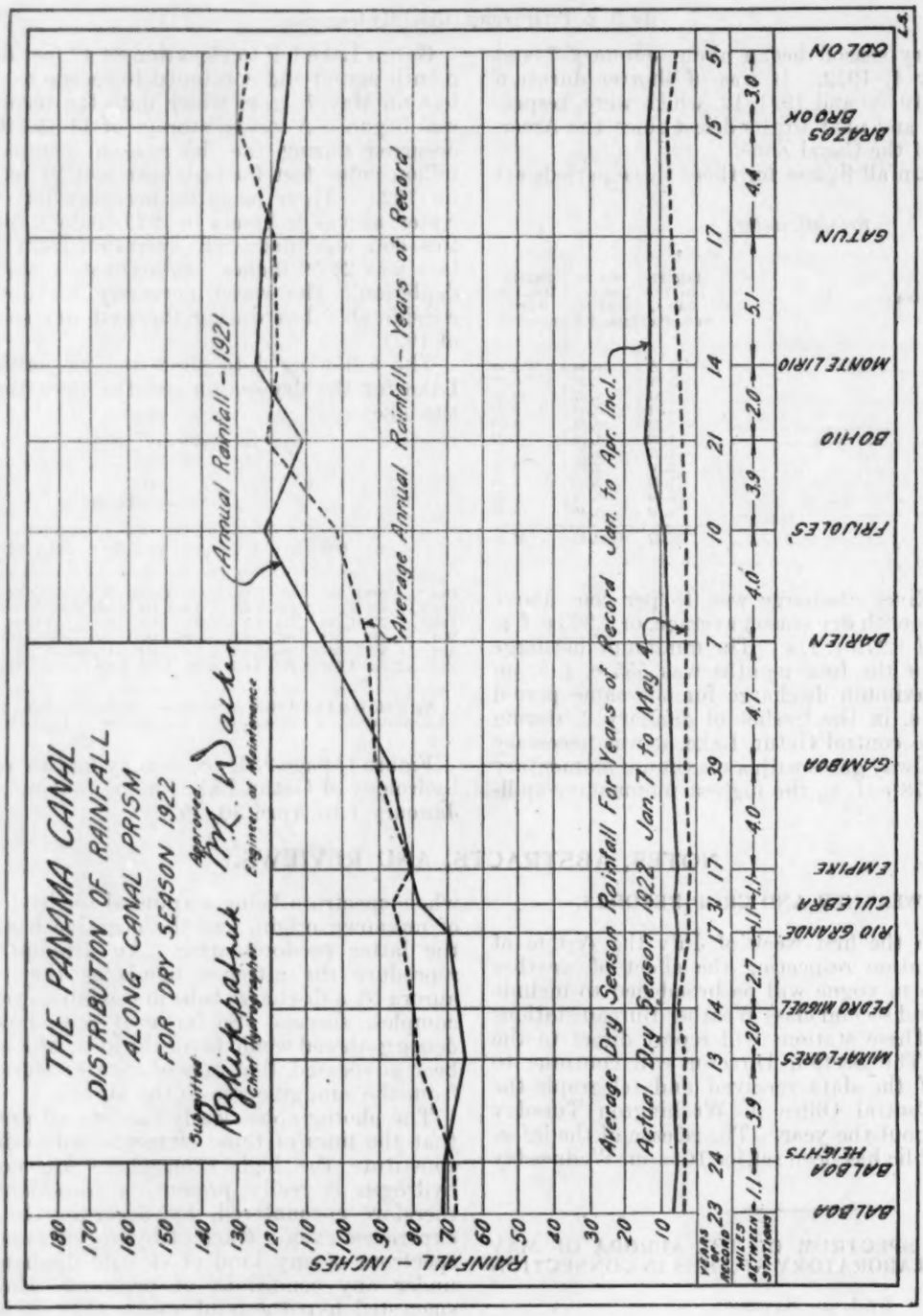


FIG. 1.—Hydrology of Gatun Lake, January 1 to April 30, 1922. (See p. 255.)

THE AURORA LINE IN THE SPECTRUM OF THE NIGHT SKY.

By LORD RAYLEIGH.

[Abstracted from *Proceedings of the Royal Society*, A100, 367-378, 1922.]

Exposures on isochromatic plates were made every night from February 26 to July 31, 1921, satisfactory records of the spectrum of the sky being obtained on 145 nights; the prism spectrograph was pointed north at an elevation of 45°. The green auroral line 5578, of unknown origin, previously found by several observers [1] to be present on ordinary nights in comparatively low latitudes, was recorded on about two nights out of three.

The intensity of the aurora line on ordinary nights does not seem to be related either to the amount of magnetic disturbance or to the transit of spots over the sun's central meridian. The observations showed quite definitely that near Newcastle the line, though not wanting, is ordinarily much less bright than near London, about 3° farther *south;* this is in agreement with the experience of others in England and America. There is no doubt of the genuine variation in intensity of the line from night to night—in general it remains strong or weak for several consecutive nights. It seems to differ in degree, kind, and origin from that in an auroral display, but the wavelength is the same.

Krypton was used as a comparison spectrum, and no doubt was left as to the fact that the krypton line is less refrangible than the aurora line. Some experiments to determine the origin of the latter were made, but the results were negative.—*E. W. W.*

[1] Weichert, *Phys. Zeit.*, 3,366, 1902; Campbell, *Lick Obs. Bull.*, 5, 46, 1908 *Pub. Astr. Soc. Pac.*, 29, 218, 1917; Slipher, *Astrophys. Jour.*, 49, 266, 1919.

AURORA BOREALIS OF MAY 13, 1920.[1]

By C. STÖRMER.

[Abstracted from *Comptes Rendus*, 172. pp. 1672-1673, June 27, 1921.]

Amongst the photographs of this aurora is a pair of special interest, taken simultaneously at Kristiania and Oscarsborg (27.36 km. apart) at 11h. 4m. 24s. G. M. T. It represents a long auroral ray, the position in space of six points of which have been determined. The heights of these points above the earth surface range from 192 km. to about 470 km., and the ray is thus remarkable for the high altitude of its lowest point as well as for the fact that it reached a level of almost 500 km. During a previous aurora, March 22-23 1920, the summits of the rays were found to be between 500 km. and 600 km.—*M. A. G.*

HEIGHT OF AURORA.[2]

By C. STÖRMER.

[Abstracted from *Geofysiske Publ.*, Kristiania, 2. No. 2, *Nature*, 107. p. 663, July 21, 1921.]

Simultaneous photographs of the brilliant aurora of March 22-23, 1921, were taken at Kristiania and Königsberg, 65.7 km. apart, the exposures being timed by telephone after the cameras were pointed to the same stars in Cassiopeia. The streamers had well-defined edges, and the heights of the ends of long rays were determined as 597, 550, 607, 562, 528, 485, and 519 km., respectively. The bases may be as low as 85 to 90 km., but the great heights of the edges are taken to indicate that the atmosphere must extend beyond 500 km.—*W. W. B.*

[1] Reprinted from *Science Abstracts*, Jan. 31, 1922, p. 38, §103.
[2] Reprinted from *Science Abstracts*, Jan. 31, 1922, p. 32, §84.

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RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

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Bassin de la Loire. Notice hydrologique. Paris. 1919. x, 74 p. chart. 27 cm.

Baker, Oliver E., & others.
Seedtime and harvest. A graphic study of seasonal work on farm crops. Washington. 1922. 53 p. diagr. 23½ cm. (U. S. Dept. of agriculture. Dept. circular 183.)

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C. F. TALMAN, Professor in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

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SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING MAY, 1922.

By IRVING F. HAND, Temporarily in Charge.

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements the reader is referred to this REVIEW for April, 1920, 48:225.

From Table 1 it is seen that direct solar radiation intensities averaged above normal for May at Washington and Lincoln and slightly below normal at Madison.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged above the May normal at Washington and slightly below at Madison.

Skylight polarization measurements made on four days at Washington give a mean of 60 per cent, with a maximum of 63 per cent on the 8th. These are slightly above the average for May. At Madison, measurements made on five days give a mean of 60 per cent, with a maximum of 66 per cent on the 13th. These are about normal values for May.

TABLE 1.—*Solar radiation intensities during May, 1922.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass.									Local mean solar time.
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	[1]1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Washington, D. C.											
May 1	7.57		0.64	0.79	0.98	1.22					4.17
8	5.79	0.87	0.99	1.10	1.27	1.53					5.79
16	10.21				0.95						6.02
19	10.21				1.16		1.17				7.57
20	9.47	0.70	0.81	0.94		1.39					7.87
23	14.10				0.73						12.68
24	10.97				0.70						12.24
25	10.97					1.29					10.59
30	9.14	0.62	0.75	0.91	1.10	1.33	1.08	0.89			8.48
Means		**0.73**	**0.80**	**0.94**	**0.98**	**(1.35)**	**(1.12)**	**(0.89)**			
Departures		**+0.10**	**+0.07**	**+0.10**	**−0.01**	**+0.05**	**+0.12**	**+0.11**			
Madison, Wis.											
May 5	6.76				1.11						6.76
7	8.48				1.16						7.29
10	14.60				0.97						15.65
11	13.13			0.83							14.60
13	7.04	0.83	0.93	1.05	1.23	1.41					6.27
17	8.81				1.08						7.87
20	10.59				0.97						10.97
27	7.87					1.48					8.48
29	7.87			0.92	1.07						10.21
Means		**(0.83)**	**(0.93)**	**0.93**	**1.08**	**(1.44)**					
Departures		**−0.01**	**−0.08**	**−0.03**	**−0.03**	**+0.09**					
Lincoln, Nebr.											
May 3	10.97				1.05						7.87
4	6.27			1.05	1.25						4.17
5	8.18				1.15						9.47
6	7.57						1.22	0.99	0.80	0.71	3.81
11	8.48						0.83				4.57
12	5.79			1.23							4.57
16	6.76				1.10						9.14
18	6.76			1.05	1.22		1.24	1.01	0.83		4.57
19	9.47					1.40	1.25	1.05			6.27
Means				**1.11**	**1.15**	**(1.40)**	**1.14**	**1.02**	**(0.82)**	**(0.71)**	
Departures				**+0.14**	**+0.01**	**+0.02**	**+0.06**	**+0.11**	**+0.06**	**±0.00**	

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning.	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Apr. 30	417	484	.....	−46	+32	.....	−1,976	−1,427	.....
May 7	534	557	.....	+56	+92	.....	−1,581	−785	.....
14	458	416	.....	−29	−57	.....	−1,786	−1,193	.....
21	501	423	.....	+10	−36	.....	−1,714	−1,587	.....

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

By C. G. ABBOT, Assistant Secretary.

[Smithsonian Institution, Washington, June 29, 1922.]

In continuation of preceding publications, the following table contains the results for the solar constant of radiation obtained at Montezuma, near Calama, Chile, in March, 1922. The values of $\rho/\rho sc$ are given at air mass 2, or, if not, the air mass is stated. The reader is referred for further statements regarding the arrangement and meaning of the table to the REVIEW for February, August, and September, 1919 (vol. 47).

Date.	Solar constant.	Method.	Grade.	Transmission coefficient at 0.5 micron.	Humidity.			Remarks.
					$\rho/\rho sc$	V. P.	Relative humidity.	
1922								
A. M.	*cal.*					*cm.*	*Per cent.*	
Mar. 2	1.874	E_o	VG..	0.858	[1]0.547	0.47	49	Cumuli forming in east.
3	1.932	E_o	E....	.870	.528	.33	33	Cloudless.
P. M.								
4	2.059	E_o	G....	.875	.561	.36	19	Cirri over high peaks.
6	1.880	E_o	G+..	.866	.612	.34	20	Some cumuli over peaks.
A. M.								
7	1.965	E_o	E+..	.871	.631	.31	31	Cloudless.
P. M.								
8	1.892	E_o	VG−	.857	.650	.22	15	Do.
10	2.003	E_o	VG−	.834	.668	.23	12	Do.
A. M.								
11	1.963	E_o	E....	.877	.727	.18	17	Do.
12	1.947	E_o	E....	.872	.728	.25	24	Do.
P. M.								
13	1.908	E_o	VG..	.876	.660	.23	90	Small patch of cumulus in north.
A. M.								
17	1.933	$M_{1\cdot31}$	S−...	.869	[2].596	.34	21	Cirri scattered about sky.
22	1.937	$M_{1\cdot34}$	S....	.879	[3].697	.27	15	Patches of cirrus in north and east.
	1.935	$M_{1\cdot28}$						
	1.936	W. M.						
23	1.957	E_o	S−...	.844	.556	.29	26	Patches of cirrus in north, forming early.
	1.928	M_3						
	1.944	$M_{1\cdot5}$						
	1.943	W. M.						
P. M.								
24	1.913	$M_{1\cdot76}$	S−...	.877	[4].611	.32	15	Clouds scattered about sky. Cirri prevented earlier observations.
	1.926	$M_{1\cdot50}$						
	1.948	$M_{1\cdot34}$						
	1.932	W. M.						
25	1.880	M_3	S−...	.879	.590	.27	12	Cirri in a. m. prevented observations.
	1.916	$M_{1\cdot61}$						
	1.934	$M_{1\cdot44}$						
	1.925	W. M.						
27	1.919	$M_{2\cdot33}$	S−...	.877	[5].545	.37	21	Considerable cirrus in north and east.

[1] Air mass 1.86.
[2] Air mass 1.31.
[3] Air mass 1.34.
[4] Air mass 1.76.
[5] Air mass 2.33.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was considerably below the normal at St. Johns, N. F., and slightly below at land stations on the coasts of Canada and the United States. It was somewhat higher than usual in the West Indies, Bermudas, Azores, and on the north coast of Scotland, while in the southern part of Ireland and England comparatively large plus departures were the rule.

Judging from reports received, the number of days on which fog was observed was not far from the normal over the Grand Banks and the greater part of the steamer lanes, as well as at land stations in the British Isles.

Ordinarily the number of observations showing winds of gale force is considerably less in May than April, and the month under discussion was no exception to the general rule. Over the northern steamer lanes gales were not as prevalent as usual, while in southern waters their number was somewhat above the normal.

On the 2d there was a moderate disturbance central near latitude 50° N., longitude 30° W. Storm log follows:

British S. S. *Poland:*

Gale began on the 1st, wind SSW. Lowest barometer 29.56 inches at 7 a. m. on the 2d, wind SW., in latitude 49° 51′ N. longitude, 29° 05′ W. End on the 2d. Highest force of wind 8; shifts S.–SW.

On the same day the observer on board the American S. S. *Trontolite* reported a most unusual mirage in the Gulf of St. Lawrence, as follows:

At 4 a. m. on the 2d, in latitude 47° 34′ N., longitude 62° 32′ W., wind calm, sky blue, observed mirage in the east of two steamers apparently upside down. They changed in form until they appeared like a statue, then finally assumed their proper shape. Afterwards the distance of these vessels was found to be about 45 miles.

On the 3d there was a LOW central near St. Johns, N. F., and while moderate SW. winds prevailed in the southerly quadrants at the time of observation, they increased to gale force later in the day, as shown by following storm logs:

Belgian S. S. *Samland:*

Gale began on the 3d, wind W. Lowest barometer 30.08 inches at 6 p. m. on the 3d, wind W., 7, in latitude 40° 30′ N., longitude 56° 05′ W. End on the 3d, wind W. Highest force of wind 12, W.; steady from W.

Swedish S. S. *Carlsholm:*

Gale began on the 3d, wind SW. Lowest barometer 29.81 inches at midnight on the 3d, wind WNW., 8, in latitude 41° 37′ N., longitude 50° 21 W. End on the 4th, wind NNW. Highest force of wind 9; shifts WSW.–SSW.

This disturbance drifted slowly northeastward during the next two days, and on the 4th moderate gales were encountered over a limited area between the 35th and 45th parallels and the 40th and 50th meridians. On the 5th gales were experienced by vessels in the eastern section of the steamer lanes. Storm log follows:

American S. S. *Sunbeam:*

Gale began on the 4th, wind WSW. Lowest barometer 29.58 inches at 2 a. m. on the 5th, wind WNW., in latitude 44′ 41′ N., longitude 35° 27′ W. End on the 6th, wind N. Highest force of wind 9; shifts W.–NW.

From the 6th to the 8th moderate weather was the rule over the entire ocean, with considerable fog on the 6th and 7th between the 60th meridian and American coast, while it was also reported over the Grand Banks and off the west coast of Ireland.

From the 9th to the 12th there was a nearly stationary disturbance central near the coast of Nova Scotia, with the storm area extending as far south as the 35th parallel. Storm logs follow:

American S. S. *Shenandoah:*

Gale began on the 9th, wind NW. Lowest barometer 29.52 inches at 6:30 p. m. on the 10th, wind NW., 10, in latitude 39° 02′ N., longitude 55° 21′ W. End on the 10th, wind NW. Highest force of wind 10, NW.; steady from NW.

Japanese S. S. *Penang Maru:*

Gale began on the 9th, wind SW. Lowest barometer 29.65 inches at 4 a. m. on the 10th, wind WNW., in latitude 36° 25′ N., longitude 55° 45′ W. End on the 11th, wind NW., 4. Highest force of wind 9, W.; steady from W.

From the 11th to the 15th three vessels reported a peculiar red mist extending from the west coast of northern Africa to the 53d meridian, caused by a fine red sand, a sample of which was forwarded to the Central Office of the Weather Bureau by Captain van Os, master of the Dutch S. S. *Yildum.* Reports follow:

Dutch S. S. *Hagno:*

At 8 p. m. on May 13th in latitude 8° 11′ N., longitude 50° 05′ W., red mist observed that makes the whole horizon very hazy. This lasted until 3 p. m. on May 15 in latitude 5° 21′ N., longitude 45° 02′ W. In this red mist was the wet air mixed with a kind of red sand and dust. Wind remained steady from NE., force 4 to 5.

British S. S. *Dundrennan:*

From May 11 to 15 in latitude 7° 47′ N., longitude 44° 26′ W., to latitude 18° 44′ N., longitude 53° 22′ W. (L. M. N.), the hazy weather recorded was apparently due to the fact that the air was laden with a very fine reddish-brown sand similar to that found in the Harmattan winds experienced off the west coast of Africa. Judging by the deposits on the ship's cordage, the amount was greatest on the 14th. Position at Greenwich mean noon, latitude 15° 32′ N., longitude 50° 34′ W.

Dutch S. S. *Yildum:*

On the night of the 11th and 12th the vessel was about 240 to 250 miles off the African coast. For more than three days the wind was N. to NE., force 1 to 5, atmosphere hazy. At daybreak on May 12 we found the vessel covered with red-brown colored dust. Sample forwarded to you was found between latitudes 14° N., and 15 °N., longitudes 22° 10′ W. and 21° 30′ W.

Capt. W. D. Barret, master of the American S. S. *Metapan*, reports:

A cyclonic storm swept the coast of Colombia between May 11 and 12. Thousands of banana trees destroyed.

Charts VIII and IX show the conditions on the 15th and 16th, respectively, when there was one fairly well-developed LOW over the middle section of the steamer lanes and another off the coast of Europe. Storm logs follow:

British S. S. *Valemore:*

Gale began on the 15th, wind S. Lowest barometer, 29.24 inches at 10 a. m. on the 15th; wind S., 7, in latitude 48° 12′ N., longitude 35° 30′ W. End on the 16th, wind W. Highest force of wind 9, W. by S.; shifts S.-W. by S.

British S. S. *Stanmore:*

Gale began on the 15th, wind E. Lowest barometer 29.18 inches at 8 a. m. on the 16th, wind E., 8, in latitude 57° 05′ N., longitude 20° 30′ W. End on the 16th, wind E. Highest force of wind 8; steady from E.

By the 17th this disturbance had decreased in intensity, but on the 18th had increased again, as shown by the following storm logs:

British S. S. *Lapland:*

Gale began on the 17th, wind NNE. Lowest barometer 29.35 inches at midnight on the 17th, wind NNW., 9, in latitude 43° 47′ N., longitude 37° 03′ W. End on the 18th, wind WSW. Highest force of wind 10; shifts N.-NNW.-NW.

American S. S. *Sarcoxie:*

Gale began on the 18th, wind SW. Lowest barometer 29.72 inches at noon on the 18th, wind SW., in latitude 47° 31′ N., longitude 25° 02′ W. End on the 19th. Highest force of wind 10, SW.; steady from SW.

From the 19th to the 27th, with the exceptions noted below, a period of fine weather existed over the entire ocean, with comparatively high pressure and slight gradients, although from the 19th to 21st fog was reported off both the American and European coasts.

On the 21st the American S. S. *Sabine Sun* encountered a most peculiar squall of short duration in the vicinity of Nassau, as shown by following report:

At 10 p. m. on the 21st passed through a fresh southerly gale, force 8, lasting 45 minutes. Wind steady from S., barometer at 30.05 inches. Position, latitude 26° 50′ N., longitude 79° 21′ W.

While a number of other vessels were near by on the 21st and 22d, this was the only report received denoting unusual conditions.

At Greenwich mean noon on the 27th high pressure and moderate winds, with fog, prevailed off the coast of Europe. In spite of that fact the American S. S. *America* encountered a severe easterly gale early in the day, as shown by following storm log:

Gale began on the 27th, wind ESE. Lowest barometer 30.36 inches at 7 a. m. on the 27th, wind ESE., 3, in latitude 48° 02′ N., longitude 16° 26′ W. End on the 27th, wind ESE. Highest force of wind 11; steady from ESE.

Charts X and XI show the conditions on the 28th and 29th, respectively. On the former date a strong NE. gale prevailed off the coast of Hatteras, and on the latter there was a disturbance of limited extent in mid-ocean. Storm logs follow.

American S. S. *El Mundo:*

On the 28th fresh NE. gales and heavy sea. Overcast and squally. Lowest barometer 29.81 inches. Greenwich mean noon position, latitude 31° 18′ N., longitude 78° 55′ W.

Italian S. S. *Mincio:*

Gale began on the 28th, wind NE. Lowest barometer 30.08 inches at 1.15 p. m. on the 28th, in latitude 36° 09′ N., longitude 73° 18′ W. End 7 p. m. on the 19th. Highest force of wind 10, N.; shifts not given.

Dutch S. S. *Noordam:*

Gale began on the 29th, wind SSW., 7. Lowest barometer 29.61 inches at 2 p. m. on the 29th, wind SSW., 8, in latitude 44° 27′ N. longitude 38° 04′ W. End at 10 p. m. on the 29th, wind NW., 6. Highest force of wind 8, SSW. Shifts SSW.–NNW.

At Greenwich mean noon on the 29th a LOW covered the greater part of the Gulf of Mexico, although at the time only moderate winds were reported from that region. Early in the morning, however, the American S. S. *Pennsylvania* encountered a severe squall from the north, as shown by following report.

Gale began on the 29th, wind N. Lowest barometer 29.85 inches at 1:30 a. m. on the 29th, wind NW., in latitude 23° N., longitude 94° 30′ W. End on the 29th, wind N. Highest force of wind 9, NNW. This gale came on suddenly and lasted one hour.

NORTH PACIFIC OCEAN.

By F. G. TINGLEY.

The month opened with an extensive area of low pressure occupying the Aleutian area and one of high pressure lying between the Hawaiian Islands and the American mainland. High pressure also covered Japan and Mongolia. Moderate northerly gales were prevailing on the western portion of the northern steamer route and southerly gales along the eastern portion. By the evening of the 2d the Aleutian depression had moved to the Gulf of Alaska, where it slowly diminished in energy, finally passing inland on the 7th. On the 9th a second depression appeared over the Aleutians and on the 11th a third and more vigorous one. Both continued to move eastward as far as the Gulf of Alaska.

Following the last-named depression, pressure rose strongly over mid-ocean, the barometer at Midway Island recording 30.30 inches on the evening of the 15th and at Dutch Harbor 30.48 inches on the morning of the 16th. This change was of brief duration, however, as pressure was falling over the western Aleutians by the evening of the latter date in connection with the advance of a depression toward Bering Sea. On the 17th high pressure prevailed over both the eastern and western portions of the ocean. On the 19th the high-pressure areas had joined in mid-ocean and the combined areas extended from the American coast to the Kuril Islands. During the next 10 days high pressure was fairly well maintained in middle latitudes, while a series of depressions of moderate size and energy moved eastward over Bering Sea and the Gulf of Alaska. At the close of the month pressure was generally low over the western portion of the ocean, with depressions centered to the south of Japan and over the Aleutians and fresh to strong northerly gales prevailing along the northern steamer routes west of the 160th meridian, west longitude. Pressure remained moderately high over eastern portions of the ocean.

During the period from about the 4th to 12th a small typhoon prevailed in the region lying east of the Philippines and Formosa. Observations from land stations failed to give any positive indication of the existence of this storm, but on the 7th and 8th the British S. S. *Anglo-Mexican* was heavily involved near 21° 30′ N., 133° E. This vessel, under command of Capt. R. P. Davis, Observer W. C. Morris, was proceeding toward Hongkong from Panama. These officers have furnished the following account of their experience in this typhoon:

May 3. Position at G. M. N., 19° 50′ N., 154° 21′ E., wind S., light, very fine, and clear, but with infrequent heavy showers, sea smooth, bar. 29.89.

May 4. G. M. N., 21° N., 150° 26′ E., similar weather, very heavy rain showers, sea smooth, bar. 29.85.

May 5. 21° 19′ N., 145° 45′ E., wind S., 1–2, very fine and clear, infrequent showers, sea slight, S., bar. 29.87.

May 6. 21° 9′ N., 141° 28′ E., wind S., 1–2, sky overcast and dull looking through night but clear through daytime, with few Fr. Nb. clouds, sea slight, S., bar. 29.86.

May 7. 21° 18′ N., 137° 10′ E., wind SE., 2, overcast with passing showers, conspicuous southerly swell, heavy lightning. At noon sky became overcast and rain started to fall in torrents, with vivid lightning. 4 p. m. Wind increasing and sea rising with increasing squalls. 6. p. m. Barometer falling and weather showing all signs of approaching storm. 10 p. m. Barometer down to 29.55, with high sea, terrific squalls of wind and rain. Midnight. Barometer falling fast, wind steady in direction and increasing in force, with incessant terrific squalls, accompanied by heavy rain, sea mountainous.

CORRIGENDUM: In the April REVIEW the maps on charts IX and XI should be interchanged.—EDITOR.

May 8. 21° 25′ N., 132° 27′ E. 12:10 a. m. Vessel hove to on starboard tack. 2 a. m. Barometer fallen to 29.37 and then steadying, wind of hurricane force and mountainous sea. 3 a. m. Wind shifting from ESE. to SE. and at 4 a. m. to SSE. At 6 a. m. glass showed signs of rising. 8 a. m. Barometer standing at 29.41, weather beginning to show signs of abating. Longer intervals between squalls evident, with slight breaks in clouds. Noon. Weather improving rapidly. The lowest barometer observed was 29.37 inches. This occurred at 2:05 a. m. on the 8th in 21° 30′ N., 133° E. Shifts of wind, ESE., SE., SSE., S., SSW.

May 9. 21° 12′ N., 128° 31′ E., wind W., 1, weather fine and clear, smooth sea, bar. 29.86.

The barometer on board the *Anglo-Mexican* was compared on arrival at Hongkong, and the correction, +0.27 inch, has been applied to the readings given.

It seems probable that the typhoon passed to the south of Guam on the 3d on a WNW. course, recurved near 21° N., 132° E., during the 7th and 8th, and passed to the west of the Bonin Islands on the 10th. Reports at hand do not show whether it then dissipated or continued on into higher latitudes.

The most extensive disturbance of the month was probably that in which several reporting vessels were involved on the 10th–13th (American time) near the 180th meridian. This appears to have been the depression that occupied the region of the Kuriles on the morning of the 10th (Asiatic time). The following reports indicate the severity of this storm.

Norwegian S. S. *Luise Nielsen*, Capt. J. U. Velde, Observer N. Jagen, Tsingtau for Astoria.

Gale began on 11th with wind at ESE.; lowest barometer, 29.38 inches, occurred at midnight of the 11th–12th in 49° 56′ N., 175° 48′ E., with wind E., force 11 (highest); gale ended on 13th, wind NNE.

British S. S. *Monteagle*, Capt. A. V. R. Lovegrove, Observer D. Smith, Yokohama for Vancouver.

Gale began on 11th in 48° 12′ N., 174° 45′ E., with wind SE.; lowest barometer, 29.28 inches, occcurred at 4 a. m. on the 12th in 48° 43′ N 178° 20′ E., wind E.; gale ended at noon of 13th, wind NNE., shifts SE. to NNE., highest force, 8.

British S. S. *Bessie Dollar*, Capt. F. Mechan, Observer D. Nicoll, second officer, Yokohama for San Pedro.

Gale began on 10th, wind ESE.; lowest barometer, 29.16 inches, occurred at noon of same day in 45° 15′ N., 176° E., wind SSE., 7; gale ended on 11th, wind SW.; shifts, SSE., SW., WSW.; highest force, 8.

Gale began on 12th, wind NNE.; lowest barometer, 29.37 inches, occurred at 8 p. m. same day in 45° 52′ N., 173° 48′ W., wind NNE., 8; gale ended on 13th, wind N., highest force, 8.

At Dutch Harbor pressure was below normal on the first three days of the month and on and after the 23d, the average departure for the combined periods being −0.34 inch. The departure for the remaining portion of the month was +0.12 inch. The lowest pressure, 29.00 inches, occurred on the 1st; the highest, 30.48 inches, on the 16th. At Honolulu pressure was above normal during the first decade by approximately 0.03 inch and fluctuated above and below by small amounts thereafter. At Midway Island conditions were not marked. For the month as a whole pressure was above normal by slightly less than 0.02 inch. The highest pressure, 30.30 inches, occurred on the 15th and 16th; the lowest, 29.94 inches, on the 20th.

(The Manila typhoon of May 23, 1922, will be described in the June issue of the REVIEW.)

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

Newfoundland.—ST. JOHNS, May 4.—This province is covered by a blanket of snow several inches deep, following a blizzard which swept over the island yesterday.

In some places the snow blocked the railway and the sealing fleet was unable to continue operations.—*Washington News, May 5, 1922.*

England.—LONDON, May 24.—The phenomenal heat wave began Friday, and is expected to continue for several days to come.

By 3 o'clock in the afternoon the thermometer registered 85 in the shade and 126 in the sun. Several deaths from heat prostration have been reported daily.—*New York World, May 25, 1922.*

In the recent hot spell the sheltered thermometer at Greenwich registered 90.2° on May 22 and 90.6° on May 24. The previous records for May since 1841 show only eight days with a temperature so high as 85, the maxima being 87.5 on May 26, 1880, followed by 87.0 on May 18, 1868, and 86.5 on May 25, 1920, while a temperature of 90 has occurred only seven times during June since 1841 and only once since 1897.—*Nature (London), June 3, 1922, p. 723.*

France.—PARIS, May 5.—Never, as far back as the longest memory of the oldest inhabitant and official records go, has Paris seen so much rain as it has since April 1. Not a day passes without at least one shower, and the majority of the afternoons are marked by a continuous downpour, spoiling the pleasure of tourists. The Seine is rising to an alarming height, and the more timid residents of Auteuil are fearing a repetition of the floods of 1910, which resulted in damage estimated at millions of francs.—*New York Herald, May 6, 1922.*

MAY 24.—Paris to-day experienced the hottest May day in 116 years, the thermometer hitting 94.1° F. in the shade at 3.45 o'clock this afternoon. Many capitals have been struck by the heat wave that began sweeping Europe five days ago.

The heat here generated a peculiarly stifling haze.—*New York World, May 25, 1922.*

Switzerland.—GENEVA, May 24.—The heat wave in the Alps region has broken a 90-year record for the month of May, the thermometer at several points to-day registering 90° F. Snow and glaciers are melting rapidly, and the Rhine and Rhone Rivers are rising.—*New York World, May 25, 1922.*

Morocco.—MADRID, May 21.—A severe windstorm swept Cueta and Tatuan, Spanish Morocco, yesterday, doing considerable damage to the positions of the troops there, says a War Office statement.—*New York Times, May 22, 1922.*

Egypt.—A message from Cairo dated May 3 stated that the low level of the Nile was causing some anxiety, notably with regard to the cotton crop. The supply from the White Nile, which provides the bulk of the summer water, has disappointed expectations, being much lower than in any year hitherto recorded. The Blue Nile was also very low.[1]

Australia.—Further heavy rains, which were much needed, fell in South Australia early in the month.[1]

Brazil.—The excessive rains in the north were harmful to the sugar-cane plantations, but the weather was favorable to the coffee crop.[1]

[1] *Meteorological Magazine*, June, 1922, p. 148.

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

The weather of the month, on the whole, was close to the normal for May. Atmospheric pressure was high on both coasts and for quite a distance into the interior, thus indicating oceanic control and the development of more than the average number of cyclonic disturbances in the Rocky Mountain region and the South. The movement of these in turn resulted in high temperatures generally east of the Rockies. To the large number of cyclones passing across the Southwest may be attributed the heavy rains of the Gulf States, including Florida.

An example of extreme weather conditions in May is found in the 48-hour snowstorm in the mountains of Colorado, New Mexico, and southern Utah on the 8th and 9th. This storm, after passing over the plains States, caused heavy snow in the mountains of South Dakota and tornadic storms locally in Nebraska.

The usual details follow.

CYCLONES AND ANTICYCLONES.

By W. P. DAY, Observer.

Cyclonic areas were numerous, but few developed storm intensity. A majority of them appeared to form over the southern portion of the country and moved slowly north and northeastward.

Only one Alberta anticyclone was charted, while five of the Hudson Bay type and seven offshoots from the North Pacific anticyclone were noted. With one exception the latter were not well defined except on the immediate Pacific coast. As a rule, high pressure on the Pacific on reaching the coast extends inland as a lobe which later separates from the oceanic high pressure and passes to the east of the Rocky Mountains, the oceanic anticyclone meanwhile apparently retreating to the westward. These offshoots are generally weak during the warmer months and reach the Atlantic with difficulty.

LOWS.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total.
May, 1922	3.0	.....	1.0	1.0	3.0	3.0	4.0	.....	3.0	18.0
Average number, 1892–1912, inclusive	2.9	1.3	1.2	0.7	1.4	0.7	0.2	0.3	1.0	9.7

HIGHS.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
May, 1922	7.0	.....	1.0	.....	5.0	13.0
Average number, 1892–1912, inclusive	1.3	0.5	3.3	0.7	0.9	6.7

FREE-AIR CONDITIONS.

By W. R. GREGG, Meteorologist.

Mean free-air temperatures for the month (Table 1) did not differ greatly from the normal, being slightly below at Drexel and above at all other stations. The greatest positive departures occurred at Royal Center, in agreement with the conditions shown in Climatological Chart III, viz, abnormally high temperatures in the States adjoining the Great Lakes. Elsewhere throughout the country there was little variation from the normal. At Royal Center the departures were less in the upper levels than at and near the surface—a condition that is usually found, viz, a greater tendency on the average to maintain a steady state in the free atmosphere than in the region below 2 or 3 kilometers.

There were no unusually high or low temperatures at any of the stations. In general the individual variations from the monthly mean were less than 5° C.; in no case were they as large as 10° C.

Relative humidities were for the most part slightly above normal; decidedly so in the extreme upper levels at Broken Arrow. There were no extended periods of exceptionally dry conditions at any of the stations.

Vapor pressures were generally above the seasonal average in conformity with the positive temperature departures. The excess was greatest at Royal Center; at Drexel there was little variation from normal conditions.

In Table 2 may be found the resultant winds for the month at the six kite stations and, for the sake of comparison, the normal values. In general there was a stronger south component than usual. Particularly was this true at Royal Center, where, it will be recalled, temperatures were abnormally high. At Drexel, on the other hand, the south component was comparatively weak and the temperatures, as previously stated, were somewhat below normal. Resultant speeds did not differ greatly from the normal at any station or at any altitude.

High winds, 30 m. p. s. or over, were observed as follows:

[By means of kites.]

Station.	Date.	Direction.	Velocity.	Altitude.
			M. p. s.	*Meters.*
Drexel, Nebr.	6	nw.	31	2,200
Due West, S. C.	19	wsw.	40	2,900

[By means of pilot balloons.]

Broken Arrow, Okla.	5	nw.	44	9,200
Do.	13	w.	40	8,500
Do.	20	w.	30	4,500
Burlington, Vt.	8	nw.	31	3,500
Camp Bragg, N. C.	19	wsw.	32	4,500
Denver, Colo.	8	sw.	30	2,000
Drexel, Nebr.	11	sw.	31	600
Do.	12	wsw.	31	2,500
Do.	15	w.	44	8,700
Ellendale, N. Dak.	2	sw.	30	600
Groesbeck, Tex.	3	wsw.	30	7,000
Do.	18	wnw.	34	10,000
Mather Field, Calif.	10	nnw.	31	4,300
Do.	24	sw.	32	6,200
Mitchel Field, N. Y.	8	nne.	35	3,000
Do.	11	n.	46	2,800
Rockwell Field, Calif.	10	nw.	30	5,200
Do.	16	wsw.	36	8,300
Ross Field, Calif.	10	nw.	45	4,800
Washington, D. C.	8	nw.	30	6,500

This table shows that with the approach of summer conditions there is a marked decrease in the number of high winds observed. Weather conditions for the month, as a whole, were unsettled and there were more than the usual number of cyclones, but with three exceptions these were comparatively weak and poorly developed. The one on the 11th to 12th, central in the Dakotas, was by far the most active and best developed during the month. This storm was nearly circular in

form and the pressure gradient in all directions from the center was very steep, the lowest pressure being 29.2 inches on the 11th. It moved slowly from western South Dakota on the 11th to northern North Dakota on the 12th, and was attended by general precipitation. It was most active on the 11th, when high free-air winds, 20 to 30 m. p. s., or more were observed at Ellendale, Drexel, Madison, and Broken Arrow. These winds, and those of lower velocity at other stations in the vicinity of this cyclone, conformed very closely with the sea-level pressure distribution. At Ellendale, for example, the wind was SSE. from the surface to 3 kilometers; at Drexel, S. from the surface to 2,500 meters; at Broken Arrow, SSW. at the surface and SW. in the upper levels; and at Denver, WNW. to W. from the surface to 3,500 meters above it. No observations were made in the northwest quadrant of this storm.

Other cases in which high free-air winds were observed over a considerable section were as follows: On the 8th along the North Atlantic coast in connection with a cyclone central over the Gulf of St. Lawrence; on the 10th along the California coast, when there was a rather sharp gradient of pressure and temperature to the eastward; and on the 18th to 20th in the central and eastern portions of the country during the eastward passage of a very vigorous and well-developed cyclone (lowest pressure 29.12 inches on the 19th at Alpena and Saginaw) from Wisconsin to eastern Ontario.

With the exception of the four cases above cited, air movement during the month was, on the whole, rather sluggish, in line with the weak pressure and temperature gradients. Easterly winds in the higher levels (above 3 kilometers) were observed on several days—5 or 6 on the average for the whole country. They were of widespread extent during two periods, viz, 22d to 24th, when they occurred over the States east of the Rockies, except Texas and Oklahoma; and 27th to 30th, when they were general over all portions of the country except southern Florida. These easterly winds were light, usually between 1 and 5 m. p. s., seldom exceeding 10 m. p. s. Surface weather changed but little during each period. For instance, a moderate cyclone central in eastern Oklahoma on the 22d had moved northward less than 200 miles by the 24th, after which it dissipated; similarly, a cyclone of small intensity but accompanied by considerable precipitation, remained in practically a stationary position just south of Mississippi and Alabama from the 28th to 31st.

On the 29th conditions were especially favorable for high balloon ascensions, because of the light winds and also exceptionally good visibility. The balloon in the morning observation at Royal Center was followed for 3 hours and 9 minutes. The rate of ascent was 180 m. p. m., and this would give an altitude of about 34 kilometers, but, as only one theodolite was used and as the behavior of balloons at great heights is uncertain, this computed altitude can not be accepted with any great degree of confidence. More especially is this true since the indicated winds during the latter part of the observation increased very decidedly in speed—a condition that would result if the balloon, as the result of a leak, ceased to rise. However, a careful examination of the record gives good reason for the belief that the balloon actually reached a height of 20 to 25 kilometers. Although the winds were light at all altitudes, three different circulations were in evidence and well-defined: (1) From the surface to 4 or 5 kilometers the winds were easterly and of low speed, 1 to 3 m. p. s. for the most part; (2) above a calm layer between 5 and 7 kilometers there were northwesterly winds of somewhat higher velocity, 5 to 10 m. p. s., extending to about 16 kilometers; and (3) from this height to about 25 kilometers the winds were northeasterly and light, 2 to 5 m. p. s. Observations at other stations and one at Royal Center in the afternoon of the same day showed good agreement as high up as they extended, viz, an easterly current from the surface to about 5 kilometers, surmounted by northwesterly winds up to at least 12 kilometers, the highest altitude reached.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during May, 1922.*

TEMPERATURE (°C.).

Altitude. m. s. l. (m.)	Broken Arrow, Okla. (233m.)		Drexel, Nebr. (396m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)	
	Mean.	Departure from normal.	Mean.	Departure from normal.	Mean.	Departure from normal.	Mean.	Departure from normal.	Mean.	Departure from normal.	Mean.	Departure from normal.
Surface..	21.4	+0.9	15.9	−0.7	20.9	−0.1	14.1	+0.4	23.5	+0.5	20.8	+3.
250.....	21.3	+1.0	.....	.....	20.6	0.0	.....	.....	22.9	+.7	20.5	+3.
500.....	19.6	+1.3	15.1	−0.8	18.5	+0.3	13.8	+.5	21.6	+1.2	18.1	+3.
750.....	18.0	+1.4	13.6	−0.5	16.8	+0.5	12.6	+.9	20.4	+1.3	16.2	+3.3
1,000.....	16.6	+1.3	12.0	−0.7	15.2	+0.4	11.1	+.9	19.2	+1.4	14.4	+3.1
1,250.....	15.0	+1.0	10.3	−1.0	13.8	+0.5	9.5	+.7	18.1	+1.4	12.7	+2.9
1,500.....	13.4	+.6	8.9	−0.9	12.6	+0.7	7.9	+.6	17.0	+1.5	11.0	+2.6
2,000.....	10.8	+.7	6.9	−0.3	10.6	+1.3	5.1	+.8	14.8	+1.7	8.0	+2.0
2,500.....	8.3	+1.2	4.2	−0.2	8.7	+2.1	2.6	+1.3	12.1	+1.7	5.0	+1.4
3,000.....	4.8	+.9	1.1	0.1	.....	.....	0.3	+1.8	8.7	+1.2	2.4	+1.4
3,500.....	1.8	+.7	−1.9	−0.1	.....	.....	−2.4	+1.7	5.0	+0.8	−0.1	+1.5
4,000.....	−1.2	+.7	−4.8	0.0	.....	.....	−5.6	+1.4	1.4	+0.8	−2.7	+1.5
4,500.....	.....	.....	−8.2	−0.3	.....	.....	−8.6	+1.2	−2.7	+0.8	−5.3	+1.5
5,000.....	.....	.....	.....	.....	.....	.....	−9.9	+1.2	−6.0	+0.8	−8.0	+1.5

RELATIVE HUMIDITY (%).

Surface..	73	−1	70	+5	68	+4	72	+8	78	+3	61	−2
250.....	73	−1	.....	.....	68	+4	.....	.....	77	+2	61	−2
500.....	71	−2	69	+5	67	+3	71	+7	76	+1	61	−3
750.....	70	−3	66	+3	68	+3	69	+7	74	+1	61	−3
1,000.....	71	−1	65	+3	70	+5	69	+7	73	+2	61	−2
1,250.....	73	+2	65	+3	69	+5	70	+7	68	0	63	+1
1,500.....	73	+6	63	+1	68	+4	71	+8	64	−1	64	+4
2,000.....	70	+7	55	−4	65	+2	70	+8	54	−2	60	+6
2,500.....	66	+7	52	−5	63	0	67	+6	46	−5	55	+8
3,000.....	68	+14	51	−7	57	−2	60	0	46	−2	45	+3
3,500.....	66	+15	50	−8	49	−3	53	−3	50	+3	45	+6
4,000.....	82	+23	49	−10	39	−5	53	−1	49	+3	43	+7
4,500.....	.....	.....	50	−11	.....	.....	57	+3	55	+3	41	+7
5,000.....	.....	.....	.....	.....	.....	.....	44	+3	.....	.....	39	+7

VAPOR PRESSURE (*mb.*).

Surface..	18.59	+0.58	12.85	+0.39	16.60	+0.68	11.67	+1.61	22.55	+1.76	15.30	+2.65
250.....	18.40	+0.54	.....	.....	16.23	+0.63	.....	.....	21.65	+1.80	14.96	+2.55
500.....	16.10	+0.37	12.10	+0.30	14.06	+0.48	11.35	+1.51	19.73	+1 91	13.07	+2.40
750.....	14.34	+0.23	10.56	+0.09	12.78	+0.43	10.16	+1.57	17.76	+1.82	11.63	+2.17
1,000.....	13.47	+0.62	9.39	−0.07	11.83	+0.50	9.17	+1.39	16.09	+1.79	10.55	+2.05
1,250.....	12.65	+1.03	8.45	−0.10	10.76	+0.55	8.34	+1.19	13.80	+1.24	9.76	+2.17
1,500.....	11.40	+1.33	7.57	−0.09	9.84	+0.55	7.61	+1.13	12.01	+1.04	8.97	+2.27
2,000.....	8.99	+1.09	5.74	−0.26	8.20	+0.53	6.08	+0.94	8.84	+0.79	7.08	+2.04
2,500.....	6.92	+.98	4.86	+0.07	6.97	+0.60	4.71	+0.73	6.38	+0.23	5.35	+1.73
3,000.....	5.71	+1.34	4.19	+0.03	.....	.....	3.56	+0.40	5.20	+0.34	3.72	+1.21
3,500.....	4.41	+0.84	3.59	+0.52	.....	.....	2.56	+0.10	4.40	+0.45	2.92	+1.02
4,000.....	4.42	+0.96	3.24	+0.70	.....	.....	1.99	+0.04	3.61	+0.31	2.73	+1.40
4,500.....	.....	.....	2.96	+0.86	.....	.....	1.63	+0.08	3.23	+0.31	2.53	+1.42
5,000.....	.....	.....	.....	.....	.....	.....	1.08	+0.08	.....	.....	2.38	+1.43

TABLE 2.—*Free-air resultant winds (m. p. s.) during May, 1922.*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (23m.)				Drexel, Nebr. (396m.)				Due west, S. C. (217m.)				Ellendale, N. Dak. (444m.)				Groesbeck, Tex. (141m.)				Royal Center, Ind. (225m.)			
	Mean.		Normal.		Mean.		Normal.		Mean.		Normal.		Mean.		Normal.		Mean.		Normal.		Mean.		Normal.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 4° E.	2.0	S. 19° E.	2.6	S. 52° W.	1.8	S. 2° W.	1.5	S. 62° E.	0.9	N. 58° E.	0.9	N. 75° W.	0.7	S. 55° E.	0.6	S. 12° E.	1.9	S. 18° E.	2.0	S. 5° E.	1.6	N. 58° E.	0.9
250	S. 5° E.	2.1	S. 19° E.	2.6					S. 64° E.	0.9	N. 56° E.	1.0					S. 1° W.	2.9	S. 11° E.	2.6	S. 7° E.	1.7	N. 60° E.	0.9
500	S. 11° E.	2.9	S. 15° E.	3.3	S. 63° W.	2.1	S. 4° W.	1.8	S. 77° E.	0.9	N. 41° E.	1.3	S. 81° W.	0.8	S. 40° E.	0.8	S. 3° W.	4.9	S. 4° E.	4.0	S. 2° W.	2.1	N. 61° E.	0.6
750	S. 9° E.	3.4	S. 4° E.	3.7	S. 87° W.	2.8	S. 8° W.	2.0	S. 82° E.	0.4	N. 20° E.	1.3	S. 54° W.	1.7	S. 19° E.	1.2	S. 15° W.	5.2	S. 4° W.	4.6	S. 17° W.	2.3	N. 9° E.	0.3
1,000	S. 4° W.	3.3	S. 8° W.	3.9	W.	3.0	S. 26° W.	2.6	S. 30° W.	0.1	N. 4° E.	1.5	S. 44° W.	1.8	S. 7° E.	1.0	S. 24° W.	5.1	S. 16° W.	4.6	S. 39° W.	2.7	N. 42° W.	0.5
1,250	S. 25° W.	4.0	S. 24° W.	4.2	S. 86° W.	3.8	S. 34° W.	2.9	S. 39° W.	1.4	N. 30° W.	1.0	S. 53° W.	2.4	S. 7° W.	2.5	S. 35° W.	5.1	S. 23° W.	5.7	S. 48° W.	3.6	N. 46° W.	1.3
1,500	S. 28° W.	4.4	S. 32° W.	4.5	S. 84° W.	4.0	S. 42° W.	3.6	S. 75° W.	3.3	S. 69° W.	1.5	S. 48° W.	3.0	S. 12° W.	2.5	S. 44° W.	5.3	S. 31° W.	5.4	S. 47° W.	3.7	N. 64° W.	1.7
2,000	S. 40° W.	6.0	S. 46° W.	4.9	S. 84° W.	5.3	S. 57° W.	4.7	S. 30° W.	4.0	S. 78° W.	1.6	S. 47° W.	3.4	S. 26° W.	3.6	S. 65° W.	5.7	S. 40° W.	5.2	S. 55° W.	4.8	N. 68° W.	2.6
2,500	S. 52° W.	6.6	S. 60° W.	5.4	N. 85° W.	7.1	S. 65° W.	5.2	S. 43° W.	4.6	S. 85° W.	2.1	S. 34° W.	4.0	S. 33° W.	5.1	S. 83° W.	8.2	S. 55° W.	5.5	S. 44° W.	4.2	N. 66° W.	3.3
3,000	S. 58° W.	7.7	S. 74° W.	5.6	N. 89° W.	10.7	S. 72° W.	7.3	S. 56° W.	1.9	N. 33° W.	2.5	S. 23° W.	5.3	S. 42° W.	6.9	S. 67° W.	8.4	S. 59° W.	6.5	S. 29° W.	1.0	N. 56° W.	3.5
3,500	N. 77° W.	8.8	N. 81° W.	8.2	S. 88° W.	13.0	S. 78° W.	8.0	W.	7.1	N. 57° W.	6.0	S. 17° W.	5.1	S. 50° W.	6.3	S. 64° W.	9.8	S. 63° W.	8.8	N. 17° W.	1.0	N. 46° W.	4.9
4,000	N. 47° W.	7.8	N. 55° W.	11.5	N. 82° W.	16.8	N. 88° W.	8.7	N. 79° W.	14.0	N. 48° W.	7.8	S. 20° W.	6.1	S. 77° W.	6.6	S. 80° W.	13.6	N. 88° W.	12.4	N. 14° W.	3.3	N. 73° W.	6.7
4,500					N. 73° W.	19.0	S. 68° W.	10.0					S. 22° W.	5.9	N. 2° E.	1.1	N. 88° W.	17.3			N. 14° W.	3.3		
5,000													S. 14° W.	5.6	N. 53° W.	8.4	S. 86° W.	17.4			S. 66° W.	1.2		

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

PRESSURE AND WINDS.

The atmospheric circulation during May assumed to a considerable extent the flattened system of isobars common to the summer season, and there was a very general slacking up of the cyclonic and anticyclonic activity that had been a rather marked feature of the weather during several months preceding.

The anticyclones had their origin mostly over the southwestern districts and drifted northeastward or eastward, usually without definite centers of action. However, near the end of the first decade low pressure developed over the middle Rocky Mountain region, and pressure remained low in that vicinity for several days, finally developing into a storm, which by the morning of the 11th had assumed definite form, central over western South Dakota. More or less precipitation occurred in the western mountain and adjacent districts during the formation of this low area, and general rains accompanied its northward movement over the Dakotas into the Canadian districts during the following few days. The falls were particularly heavy in the Black Hills region and locally elsewhere in the Dakotas and portions of adjoining States. During the early formative period of this storm heavy snows fell in southwestern Colorado and adjacent portions of Utah and Arizona, the fall in southwestern Utah being the heaviest ever recorded in May. Light snow extended over considerable areas, particularly to the westward, reaching Roseburg, Oreg., where it was observed in May for the first time in nearly 50 years.

During much of the first and second decades pressure remained comparatively low over southern districts, and local rains, heavy in many localities, persisted for considerable periods, particularly in the Gulf and South Atlantic States and over portions of the Ohio and middle Mississippi Valleys. By the morning of the 18th low pressure had concentrated into a trough formation extending from the upper Mississippi Valley southeastward to the Carolinas, and during the following 24 hours assumed a definite cyclonic formation central over the lower Lakes. This was attended by general precipitation from the Mississippi eastward, the falls becoming heavy locally near the storm center. This storm quickly lost force, however, and passed down the St. Lawrence Valley without material precipitation.

During the last decade of the month shallow cyclones moved in irregular courses over the central valleys and southern districts, and precipitation was frequent and locally heavy over much of the country from the middle and southern Great Plains eastward.

Anticyclones moving southward from the Hudson Bay region dominated the northeastern districts during much of the month, while in the far Northwest offshoots from the permanent high area over the North Pacific reached the coast on a number of dates, but usually did not materially influence weather conditions to eastward of the Rocky Mountains. In the region between the Great Lakes and Rocky Mountains and thence southward there was a notable absence of anticyclones, particularly of those frequently moving southward from the Alberta district.

For the month, as a whole, pressure was highest and materially above normal over the far Northwest, with a secondary high area over the Northeastern States, where the average pressure was likewise appreciably above normal. Over the central valleys and southern districts the average pressure was comparatively low and generally somewhat less than normal.

Compared with the preceding month the pressure was less in all districts save the extreme Northeast, the falling off being quite large over the southeastern States and along the California coast.

Winds over the districts from the Mississippi Valley eastward did not reach high velocities, as a rule, save in connection with local thunderstorms, which were widely scattered both as to location and time. On the other hand, over the Great Plains and thence westward high winds were confined mainly to definite localities and dates. Over the middle and northern Great Plains and the adjacent eastern foothills of the Rocky Mountains high winds prevailed over large areas in connection with the well-developed cyclone that moved northward over those districts on the 10th and 11th. Also in the Plateau region high winds prevailed over extensive areas on the 25th. A more complete statement of the severe storms of the month appears at the end of this section. The prevailing direction of the winds is graphically shown on Chart VI.

TEMPERATURE.

In the absence of important changes in atmospheric pressure, daily temperature variations were likewise small, 24-hour changes of 20° or more occurring in only a

few instances, mostly in the western mountain districts. From the Rocky Mountains eastward the month, as a whole, was warmer than normal, and distinctly so over the central and northern districts; in the region of the Great Lakes the average excess ranged from 6° to 9° per day, and the month was among the warmest of record. Only a few days had temperatures below normal.

In the Rocky Mountain and Plateau regions there was usually a slight deficiency in the monthly means, but over the Pacific coast States from Oregon southward the month was slightly warmer than normal. In many portions of the far West May is the first month of the present year having temperatures above normal.

The important warm periods of the month were near the end of the first and the beginning of the second decade over the central valleys and Gulf States, and generally during the last decade in the regions from the Great Plains westward and over portions of the Northeast. Maximum temperatures were above 90° at some time during the month in all the States, and they were above 100° at points in Texas, Arizona, Colorado, and Nevada—the highest, 111°, occurring in California.

Cool periods were mainly on the first day of the month from Missouri, Arkansas, and Louisiana eastward and northeastward to the Atlantic coast, and from the 9th to the 12th from the Great Plains westward. During this period minimum temperatures in portions of the Plateau and Pacific coast States were as low as, and in a few cases lower than, ever before observed in May.

PRECIPITATION.

Rain was generally abundant, and in many sections far above normal, from Texas and Oklahoma eastward. The falls were particularly heavy in the Middle and East Gulf States, where the average excesses by States ranged from 2 to nearly 4 inches. In the Ohio and middle Mississippi Valleys precipitation was of frequent occurrence and at times heavy, but the monthly amounts were usually slightly less than normal, particularly in portions of Iowa and Missouri. Over most other districts precipitation was slightly less than normal, although marked deficiencies were not evident over extensive areas. In a few southern localities the precipitation was the greatest of record for May, notably at Charleston, S. C. The severe drought over portions of southern Florida that had existed for an unusual period was effectively broken.

SNOWFALL.

The areas having snowfall during May, 1922, were confined to the more elevated mountain regions of the West. Some heavy falls occurred near the end of the first decade from northern Arizona and southwestern Colorado and southern Utah northward to Wyoming and the Black Hills region of South Dakota. In some localities the snow during this period was the heaviest ever observed in May. In the high mountains of California and thence northward to Washington there were local heavy falls, in a few cases amounting to 3 feet or more. In other mountain districts snow was more or less general, but the amounts were usually small.

The continued cool weather in the far western districts up to May prevented rapid early melting to that time, so that stored amounts in the high mountains are now greater in many localities than usual at this period of the year. The warmer weather of May accelerated melting, and the streams fed from the melting snow were usually well filled.

RELATIVE HUMIDITY.

The excessive rainfall in the Gulf and South Atlantic States was reflected in the average relative humidity of that section, which ranged up to 15 per cent or more above the normal for the month. Rather humid conditions likewise prevailed over the Great Plains region, where there were frequent rains, although the average precipitation was usually slightly less than the normal.

In the districts from the Rocky Mountains westward the relative humidity was almost universally less than normal, and there was likewise a general deficiency in the monthly precipitation. From the Great Lakes eastward to the Atlantic coast the average relative humidity was generally less than normal, and there was likewise a very general deficiency in the precipitation over the same region.

Some unusually low relative humidity values were noted at the local noon observations on several distinct dates, notably from the 8th to 10th over the Atlantic coast districts, where, under the influence of anticyclonic conditions, humidity readings under 20 per cent were observed at a number of points. Likewise in the middle Mississippi Valley, and extending eastward to Lake Michigan and Indiana, on the 13th low-humidity readings were observed. At Chicago, Ill., 22 per cent was observed at the noon observation, and later in the afternoon a value of 17 per cent was observed, probably the lowest ever recorded in the history of the station. Values only slightly above 20 per cent were observed at a number of other points in the district. The pressure was not high at the time, but north to northwest winds prevailed and a cyclone of small proportions was moving into the region from the Dakotas.

SEVERE LOCAL STORMS.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau.]

Place.	Date.	Time.	Width of path. (yards).	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
Northfield, Minn. (near)	3	P. m.	25		$1,400-$3,000	Tornado	Two persons injured and considerable property damage done.	Official, U. S. Weather Bureau. Tribune (Minneapolis, Minn.)
Trimbelle, Wis.	3	P. m.				do	A church, general store, and several farm buildings wrecked.	Capital Times (Madison, Wis.)
Austin, Tex., and vicinity	4	P. m.		13	500,000	Tornadoes (2)	Heavy property damage and about 50 persons injured.	Official, U. S. Weather Bureau. Dallas Morning News (Tex.). Austin American (Tex.) (2).
West and northwestern Oklahoma.	8			3		Tornadoes and heavy rain.	More than a dozen persons injured and property and farm damage amounts to several hundred thousand dollars.	New York Sun Wichita Eagle (Kans.).
Telluride, Colo., and vicinity.	8-10					Snow and wind	Heaviest damage sustained by Electric Power Co. Three feet of snow.	Daily Sentinel (Grand Junction, Colo.). Telluride Journal (Colo.).
Hays, Kans. (near)	10	P. m.				Tornado	Building and fence destroyed	Official, U. S. Bureau of Plant Industry.
Lexington, Nebr. and vicinity.	10	P. m.		3	100,000	do	Several persons believed dead. Homes damaged, trees broken, and farm buildings demolished. All avenues of communication closed.	Times (Denver, Colo.). Post (Chicago, Ill.). Pioneer Press (St. Paul, Minn.).
Chugwater, Wyo. (near)	10					Blizzard	Telephone service to eastward suffers. Damage to fruit crop feared.	Do.
East St. Louis, Ill., and vicinity.	10	P. m.		2		Electrical, wind and rain.	Several persons injured and minor property damage reported.	Official, U. S. Weather Bureau.
Central S. Dak.	10					Wind	Numerous buildings destroyed on farms and in small towns.	Courier News (Fargo, N. Dak.).
Galchutt, N. Dak., and vicinity.	10	P. m.				Electrical, wind and hail.	Considerable damage to farm buildings; a child injured.	Do.
La Moure, N. Dak. (near)	10	A. m.			50,000	Thunderstorm	Damage principally to farm buildings; 2 persons injured and live stock killed.	Do.
Rocky Mountain States from Arizona to Montana.	10-11					Wind and rain and snow.	Fruit damaged, train and wire service affected. Damage thousands of dollars.	Do.
Minnesota, especially Pennington County.	10-11			1	15,000	Tornado, electrical, wind and rain.	Heavy property damage; many buildings destroyed.	Pioneer Press (St. Paul, Minn.).
Osage, Iowa (near)	11					Tornado and electrical.	Silo and trees blown down; 4 horses killed by lightning.	Charles City Press (Iowa).
Eagle Pass, Tex.	14	7 p. m.			50,000	Tornado	Buildings damaged; 5 persons injured	Official, U. S. Weather Bureau.
McLennan and Williamson Counties, Tex.	14-15				30,000-50,000	Tornado, wind, rain, and hail.	Severe damage to crops and overhead wires. Also considerable property damage and several persons injured. Train derailed.	Official, U. S. Weather. Bureau. Dallas Morning News (Tex.).
Princeton, N. C.	15			1	500,000	Wind and hail	Tobacco and cotton crops destroyed; 15 persons hurt.	Morning Sun (Binghamton, N. Y.).
Bayonne, N. J.	16				1,000,000	Thunderstorm	Fire caused by lightning striking oil tank	Press (Binghamton, N. Y.).
Nueces County, Tex., and vicinity.	17	A. m.			1,000,000	Tornado, wind, and hail.	30,000 acres of cotton damaged; other crops injured. Many persons injured and small animals killed. A number of houses destroyed and others damaged.	Official, U. S. Weather Bureau. Dallas Morning News (Tex.).
Alexander County, N. C.	18	7 p. m.	175		12,500	Tornado	Buildings and timber destroyed; 5 persons injured.	Official U. S. Weather Bureau.
Barker, Tex.	20	4 a. m.			5,000	do	Buildings blown over; crops injured	Do.
Natchez, Miss., and vicinity.	20	P. m.		2	100,000	Wind	Many buildings unroofed; wires and trees down; 2 lives lost when boat capsized.	Times-Picayune (New Orleans, La.).
New Orleans, La.	20	5 p. m.				Thunderstorm and squall.	Minor damage to telephone and other wires; trees damaged; 2 persons hurt by flying debris.	Do.
Garfield County, Okla., and vicinity.	21			1	1,000,000	Tornado	Many houses wrecked; crops devastated; 1 person hurt.	Wichita Beacon (Kans.) Evening Star (D. C.).
Shawnee, Okla.	21			1		Wind	Theater, garages, and farm buildings wrecked; electric facilities out of commission; 2 persons injured.	Evening Star (D. C.). Times-Record (Fort Smith, Ark.)
Walnut Springs	21	P. m.			400,000	Thunderstorm, wind, and heavy rain.	Crops, roads, and bridges damaged	Official U. S. Weather Bureau.
Dallas, Tex.	22	A. m.			45,000	Thunderstorm	Structures at amusement park burned	Dallas Morning News (Tex.).
Northern Louisiana	22	P. m.			500,000	Wind and rain	Loss in oil fields heavy. Several houses wrecked and other minor damage. Wire communication interrupted and crops considerably hurt.	Shreveport Times (La.). Times-Picayune (New Orleans, La.).
Chicago, Ill., and vicinity	25	P. m.		1		Electrical and rain.	Streets flooded, traffic delayed, and several buildings slightly damaged. Loss amounts to thousands of dollars.	Tribune (Chicago, Ill.).
Janesville, Wis.	25	P. m.				Cloudburst	Heavy property damage, streets blocked by debris and crops hurt. Damage estimated at thousands of dollars.	Sentinel (Milwaukee, Wis.).
Burlington, Iowa	26	P. m.				do	Thousands of dollars damage in manufacturing and jobbing district.	Charles City Press (Iowa).
Dyer, Ark.	26	P. m.			10,000	Wind	Church wrecked, several residences damaged, and a number of barns and shade trees destroyed.	Official, U. S. Weather Bu-

STORMS AND WEATHER WARNINGS.

WASHINGTON FORECAST DISTRICT.

There were few storms during the month of sufficient intensity to justify storm warnings, although small-craft warnings were issued for portions of the Atlantic or the east Gulf coast on the 17th, 18th, 27th, 28th, 29th, and 30th.

Northeast storm warnings were displayed at 10 p. m. of the 4th from Sandy Hook, N. J., to Portland, Me., in connection with a disturbance of moderate intensity moving northeastward over the Middle Atlantic States and a stationary HIGH over northern New England and the Canadian Maritime Provinces. The following morning the display of warnings was extended to Eastport, Me. Verifying velocities were reached at New Haven, Nantucket, and Eastport.

No further storm warnings were required until the evening of the 18th, when southeast warnings were ordered displayed from Delaware Breakwater to Eastport, Me. At this time there was a strong and almost stationary HIGH off the north Atlantic coast and an area of abnormally low pressure from the Mississippi River eastward to the middle Atlantic and south Atlantic coasts. Verifying velocities were reported from Atlantic City, New Haven, and Boston.

A disturbance that remained almost stationary for several days in the Gulf of Mexico a short distance east of the mouth of the Mississippi River was attended by strong easterly winds at Mobile and Pensacola on the 29th and for which northeast storm warnings were issued at 9:30 p. m. of the 28th. This disturbance finally moved inland over the east Gulf States on June 1.

Frost warnings were issued for the cranberry bogs of New Jersey on several dates, for northeastern New York on the 8th and for northern New England on the 26th.—*Charles L. Mitchell.*

CHICAGO FORECAST DISTRICT.

The month of May in the Chicago Forecast District was marked by slow and erratic storm movement, frequent precipitation, and temperatures generally above the seasonal average. No storms of importance crossed the Lake region except the one of the 6th–7th, which caused verifying wind velocities only over Lake Huron and most of the Lower Lake region, Buffalo, N. Y., reporting a maximum of 60 miles an hour from the west on the 7th. No storm warnings were ordered in connection with this disturbance, except at Alpena, Mich., local action being taken by the Official in Charge at that station on the morning of the 7th.

Damaging frosts did not occur at any time during the month east of the 100th meridian, but warnings for frost and freezing temperature were issued for Montana and Wyoming on the 8th, 9th, 10th, 11th, 12th, 13th, 15th, 21st, 22d, 26th, 27th, and 30th, and for the western portions of South Dakota and Nebraska on the 11th and 15th.

Special daily fire-weather forecasts were sent to the Forest Supervisor at Cass Lake, Minn., from the beginning of the month until the 9th, with which message the service was discontinued.

Special warnings were sent to the Wisconsin cranberry marshes on the 13th, 27th, and 31st, but the bogs were flooded in anticipation of these frosts and no damage resulted.

Beginning May 11 and continuing during the month special a. m. forecasts for the benefit of fruit growers in their spraying operations were telegraphed daily to Mr. L. K. Jones, Sturgeon Bay, Wis. These forecasts have usually covered a period of several days. This service is in connection with the research work on fruit diseases in the Door County district of Wisconsin which is being carried on by the College of Agriculture in the State University.

A special forecast service covering a three-day period for Lower Michigan was begun during the latter part of the month, the forecasts being telegraphed Friday mornings to the Official in Charge, Lansing, Mich., for publication in the *Weekly News Letter* of the Michigan State Farm Bureau, through which the special forecasts are distributed to a large number of subscribers throughout the State.

The special weekly forecast service covering the week-end was continued to the editor of the Reporter-Enterprise, Oconto, Wis.

In accordance with instructions from the Central Office, special forecasts were made as follows on May 30 and 31 for the National Balloon Race at Milwaukee, Wis., on the 31st:

May 30, 9:44 a. m.

Indications now point to rather unfavorable conditions for start on Wednesday, as showers are probable. However, as the area of high pressure over the northern Rockies this morning moves slowly eastward and southward fair weather is likely after Wednesday. Winds aloft will probably be moderate to fresh westerly Wednesday and Thursday.

May 30, 9:00 p. m.

No change indicated in morning forecast. Western high-pressure area has spread southeastward slowly, but center remains over eastern Montana with diminished pressure.

May 31, 10:00 a. m.

Shallow low-pressure area centered over southern Lower Michigan this morning will move northeastward to-night and Thursday. High-pressure area over Plains States will move slowly southeastward in rear. Showers and possibly thundersqualls indicated next 36 hours, Lower Michigan, Lake Huron, Lower Lake Region, and Ontario, but gradually clearing as far east as Lake Huron by Thursday morning. Rain at Milwaukee will end this afternoon, but clouds will probably not break away until later. Surface winds at start will be moderate northerly, but winds will be westerly aloft, especially above 500 meters, force will probably be from 6 to 10 meters per second, continuing about the same Thursday. No strong winds likely.

May 31, 1:10 p. m.

Shallow trough of low pressure now reaching from southern Lake Huron southwestward and high-pressure area over South Dakota will continue generally eastward movement next 36 hours. Moderate northerly winds will prevail at start at surface with low clouds and probably up to 500 to 1,000 meters. Higher up wind will be more westerly and at about 2,000 meters possibly west-southwest with force from 10 to 15 meters per second. Advise reaching high elevations immediately in order to encounter favorable wind direction and velocity. Clouds will probably continue along entire course.

As advised in the last message telegraphed to Milwaukee on the afternoon of May 31, several of the contestants endeavored immediately to reach a high elevation in order to encounter the westerly movement, but Maj. Oscar Westover, of Washington, the winner of the race, piloting an Army balloon, was the only one who was able to maintain his balloon at a high altitude. He was carried rapidly eastward and landed near Lake St. John, about 100 miles north of Quebec, covering a distance of approximately 900 miles from Milwaukee. Some of the balloonists were able to drift at a high elevation until after crossing the State of Michigan, when, for one

reason or another, they were forced to lower elevations and encountered northerly winds, so that, unless they landed, they were in danger of being carried in a southerly direction. Others, in starting, apparently chose to drift with the northerly winds prevailing below 1,000 meters and were carried south-southwestward from Milwaukee. Mr. H. E. Honeywell, of St. Louis, Mo., an independent pilot, and Lieut. W. F. Reed, of Mobile, Ala., representing the Navy, the winners of second and third places, respectively, landed in southern Missouri, covering a distance of between 500 and 600 miles.—*E. H. Haines.*

NEW ORLEANS FORECAST DISTRICT.

Small-craft warnings were displayed on the Texas coast on the 1st, 8th, 9th, and 10th, being changed to southeast storm warnings on the 1st at 3 p. m. These warnings were justified. Thunderstorms on the east coast of Texas were attended by gales for a brief period, about 8:30 a. m. on the 15th, for which no warnings were displayed.

A disturbance of moderate intensity near the eastern and middle Gulf coasts prevailed from the 25th to the 31st. It was sufficiently intense to warrant the display of northeast storm warnings during the night of the 28th and the following day and night. Warnings were displayed accordingly on the Louisiana coast.

Warning of frost in the Texas Panhandle and extreme northwestern Oklahoma was issued on the 11th.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

An area of low pressure which began to develop over the southern Rocky Mountain Plateau on the 6th and another disturbance which appeared over British Columbia and Alberta on the same date formed, during the 7th, a trough which extended from the two Canadian Provinces already mentioned southward to northwestern Mexico. On the morning of the 10th the same storm was central over western Colorado, whence it moved slowly northeastward, reaching Manitoba during the 12th. Precipitation occurred in every portion of this district, except southern New Mexico, at some time during the period from the 7th to the 11th, with heavy snows in southwestern Colorado, northern Arizona, and southern Utah on the 9th and 10th. Freezing temperatures followed the disturbance on the 9th in southern Utah and northern Arizona, on the 10th in southwestern Colorado, and on the 11th in extreme north-central and northwestern New Mexico. Night temperatures below freezing continued in most of this area until the morning of the 13th. The passage of the storm center was also attended by gales in Colorado and New Mexico on the 10th, which continued in northeastern Colorado on the 11th. The cold weather and rain and snow were unfavorable for live stock, especially newly shorn sheep and lambs, although there appears to have been but little loss. On the morning of the 12th the temperature was decidedly below freezing in the Gunnison Valley fruit district, reaching 25° at Hotchkiss, but no serious injury to the fruit appears to have been caused by these conditions.

Showers also fell in all except the extreme southwestern portion of the district on the 14th–15th, followed on the 16th by temperatures below freezing in the western valleys of Colorado, due to an area of high pressure which extended from the north Pacific coast southeastward to the Panhandle of Texas on the morning of that date. The fruit, however, again escaped injury.

A number of LOWS that moved across the Rocky Mountain region during the latter half of the month were attended by occasional showers in Colorado and Utah, and generally showery conditions on the eastern slopes of Colorado and New Mexico during the last three days accompanied a moderate LOW which occupied most of the southern plateau region, with its center over Arizona.

Frost warnings were issued as follows: For eastern Colorado on the 10th, 11th, and 13th; east of the mountains in New Mexico on the 11th; north-central and northwestern New Mexico on the 13th and 21st; north and west Utah on the 1st and 8th; north Utah on the 10th, 11th, and 26th; and for all of Utah on the 12th. These warnings were generally verified either by the occurrence of frost or temperatures at which frost might be expected.

Light frosts for which no warnings were issued occurred at Grand Junction on the 2d, Modena on the 14th and 21st, and Denver on the 16th.

Freezing temperatures were forecast as follows: At the higher elevations of southern Utah on the 2d and 26th; all of Utah on the 9th; southern Utah on the 10th and 11th; the western valleys of Colorado on the 10th, 11th, 12th, 13th, and 16th; north-central and northwestern New Mexico on the 10th, 11th, and 12th; and at the higher elevations of northern Arizona on the 26th. The forecasts, as a rule, were justified, except in northern Utah on the 10th.

A warning of frost and freezing temperature if the weather cleared was also issued for the western fruit valleys of Colorado on the evening of the 8th, when the conditions were especially critical. Continued cloudy weather and the development of a secondary storm over southern Utah prevented a fall in temperature to a dangerous degree.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT.

The Aleutian center of activity was in evidence the greater portion of the month. It sent out no less than six offshoots that affected the weather in the northern portion of this district. The permanent North Pacific HIGH sent out four offshoots that had a more or less marked influence on the weather in the Pacific States.

The LOW on the 7th from Alaska united with a disturbance that streamed northward from Arizona, and it caused quite general rains in California and the North Pacific States.

On the 17th another LOW moved north from Arizona and apparently united with one from the Northwest on the 20th. Considerable rain fell during this period, and a live-stock warning was issued on the 18th for eastern Oregon, eastern Washington, Idaho, and northern Nevada. It was not so windy nor were the rains so cold as expected; therefore this warning was only partly verified.

Another trough-shaped depression formed over California and the region between the Cascades and Rocky Mountains on the 24th. The next morning it presented such features as to call for a live-stock warning in Idaho, which was issued and was fully verified.

The North Pacific HIGH about the 15th receded from off the California coast, which caused a relatively low barometer and unsettled weather to prevail for several days in California and over the ocean to the westward. This unsettled condition culminated in general rains in

California on the 18th and 19th. After these rains had ceased the North Pacific HIGH resumed more nearly its normal position off the California coast.

One small-craft and four storm warnings were issued for one or more sections, and 12 frost warnings were sent to North Pacific stations, most of which were verified.—*E. A. Beals.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

At the close of the month of May the Mississippi River was still in flood from Natchez, Miss., to the mouth of the river, and the Yazoo and Atchafalaya Rivers also remained in flood. A summary of the lower Mississippi floods will appear in the MONTHLY WEATHER REVIEW for June, 1922.

Aside from the lower Mississippi flood there were no floods of consequence during the month except in the rivers of Texas and in the Colorado River, the latter continuing at the close of the mouth. The annual rise of the Columbia River was also in progress.

The Santee River has been in flood since February 3, 1922, and remained so at the end of the month. Other rivers of the Carolinas were in moderate flood at different times during the month of May. Warnings were issued when necessary, and no damage was done, as previous rains had delayed planting and live stock had been removed from the lowlands.

The flood in the lower Tombigbee River of Alabama was of similar character, and moderate floods in the interior rivers of Ohio were without special incident.

The Illinois River fell steadily, but was still generally in flood at the end of the month.

The floods in the Red and Sulphur Rivers, while not severe, caused considerable apprehension. These floods began directly after the heavy rainfalls of April 26 and 27, and flood warnings were immediately issued.

Damage amounted to about $15,500, and property to an estimated value of $5,000 was reported as having been saved by the flood warnings. There was, however, considerable further delay in the cultivation of crops on lowlands that remained under water from previous floods.

The floods in most of the rivers of Texas were severe, and in some instances were the highest of record. The ground had become well saturated from the heavy rains of the latter part of April, and the streams were already much above their normal stage. Consequently, the additional heavy rains of the first decade of May caused floods that were certain to prove destructive despite the frequent warnings that were issued.

The Neches River flood again covered the lowlands for a distance of about 6 miles on the left side of the river, with additional damage amounting to about $10,800. Value of property saved through the warnings, $1,000. The highest stage reported was 27.5 feet at Rockland, Tex., on May 5, flood stage being at 20 feet. The highest stage in the Sabine River at Logansport, La., was 31 feet on May 1, 7 feet above the flood stage. Losses, $105,000. Value of property saved through warnings, $170,000.

There were two floods in the Trinity River, one continuing from April and the other beginning after the heavy rains of May 8 and 9. The crest stage reached at Liberty, Tex., was 28.6 feet, 3.6 feet above the flood stage and 0.2 foot above the previous high-water record of January 31, 1920.

Losses and damage were of the usual character and amounted to about $308,000, and the value of property saved through the warnings, $67,500.

The Brazos River flood was the most destructive of all, with a crest stage at Kopperl, Tex., of 48 feet, 27 feet above the flood stage and 11.5 feet above the previous high-water record of November 8, 1918. Below Kopperl stages were relatively more moderate, but the damage and losses amounted to about $1,742,700, of which about two-thirds was in prospective crops. Estimated value of property saved through warnings, $415,500.

The Guadalupe River was in flood during the early days of the month. Crest stages were 30.3 feet on May 5 at Gonzales, 8.3 feet above the flood stage, and 23.2 feet on May 9 at Victoria, 7.2 feet above flood stage. Warnings were issued as required, and the losses were small.

The Colorado River flood was severe and the losses amounted to about $800,000, of which $700,000 were in potatoes alone, 15,000 acres having been ruined. Crest stages were from 4 to 10 feet above flood stage, and several levees gave way. Bridges were damaged and railroad tracks washed out. Maj. F. D. Lockland, viewing the river from an elevation of 7,000 feet, said, "We saw the river in Wharton County 10 miles wide, a winding, silvery expanse of flood drifting to the sea, and spreading out over the prairie so as to make it impossible to follow the bed of the river." Warnings were timely and accurate.

Floods in the Colorado River of Colorado, Utah, Arizona, and California.—Temperatures were generally above normal during the first decade of the month, and the water from the melting snows caused a sharp rise in the upper Colorado River and its tributaries. Warnings were first issued on May 4 for the lower Colorado and repeated thereafter as occasion required. Warnings were also issued for the upper portion of the drainage basin, beginning with May 6. On May 12 a crevasse occurred in levee on the right bank of the river at Hauser Bend, in the Palo Verde Valley, near Ripley, Calif., and it has been reported that the crevasse finally attained a width of 1,300 feet, carrying most of the river discharge at that point, and returning to the river at the south end. The total area of the Palo Verde Valley is about 90,000 acres. Thirty thousand acres were inundated, of which 10,000 are under cultivation and include the towns of Ripley, Palo Verde, and Rannels. There was no loss of life, but the damage amounted to probably $1,000,000. The crest of the levee was 9 feet above the water when the crevasse occurred.

There were also some floods in the San Joaquin River of California and tributaries, and press reports state that much damage was done to growing crops. Some of these floods were in progress at the end of the month, and effort will be made to secure further information.

Flood stages during May, 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.					
Roanoke:	*Feet.*			*Feet.*	
Weldon, N. C.	30	20	21	34.3	21
Neuse:					
Neuse, N. C.	14	19	19	14.7	19
Smithfield, N. C.	14	20	22	15.0	21
Saluda:					
Pelzer, S. C.	7	5	6	10.0	5
	7	17	17	8.0	17
Chappells, S. C.	14	17	20	16.6	19
Santee:					
Rimini, S. C.	12	(1)	14	13.6	10
	12	17	(2)	14.7	23
Ferguson, S. C.	12	(1)	(2)	13.5	24
EAST GULF DRAINAGE.					
Apalachicola:					
River Junction, Fla.	12	7	8	12.3	8
Blountstown, Fla.	15	8	9	15.2	8
	15	31	(2)	15.5	31
Tombigbee:					
Demopolis, Ala.	39	6	12	42.6	9
GREAT LAKES DRAINAGE.					
Sandusky:					
Upper Sandusky, Ohio.	13	21	21	13.0	21
MISSISSIPPI DRAINAGE.					
Walhonding:					
Walhonding, Ohio.	8	20	20	9.0	20
Scioto:					
La Rue, Ohio.	11	20	21	12.0	20
	11	27	27	12.0	27
Circleville, Ohio.	10	28	28	11.0	28
Ohio:					
Shawneetown, Ill.	35	(1)	1	35.2	1
Cairo, Ill.	45	(1)	7	50.9	1
Des Moines:					
Ottumwa, Iowa.	10	27	27	10.0	27
Illinois:					
Henry, Ill.	7	(1)	(2)	12.9	1
Peru, Ill.	14	(1)	12	17.4	1
	14	27	(2)	15.0	28
Havana, Ill.	14	(1)	19	19.9	1
Beardstown, Ill.	12	(1)	(2)	22.4	1
Pearl, Ill.	12	(1)	22	20.8	1
James:					
Huron, S. Dak.	9	(1)	8	10.0	1
	9	12	20	11.4	19–21
Osage:					
Tuscumbia, Mo.	25	(1)	1	25.9	1
St. Francis:					
Marked Tree, Ark.	17	(1)	3	17.2	1
Yazoo:					
Yazoo City, Miss.	25	(1)	(2)	31.9	1, 4–6
Tallahatchie:					
Swan Lake, Miss.	25	3	29	27.7	13–17
Petit Jean:					
Danville, Ark.	20	5	6	21.0	5
	20	8	9	20.6	9
Black:					
Black Rock, Ark.	14	(1)	8	15.7	1–2
Mississippi:					
Keokuk, Iowa.	14	(1)	3	14.8	1
Warsaw, Ill.	17	(1)	2	17.5	1
Quincy, Ill.	14	(1)	5	16.4	1
Hannibal, Mo.	13	(1)	8	16.8	1
Louisiana, Mo.	12	(1)	8	15.4	1
Grafton, Ill.	18	(1)	9	22.7	1
Chester, Ill.	27	(1)	3	27.9	1
Cape Girardeau, Mo.	30	(1)	5	33.3	1
New Madrid, Mo.	34	(1)	9	40.7	1
Memphis, Tenn.	35	(1)	13	42.2	1
Helena, Ark.	42	(1)	18	53.1	3
Arkansas City, Ark.	48	(1)	23	57.7	3–5
Greenville, Miss.	42	(1)	22	52.0	3–4
Vicksburg, Miss.	45	(1)	30	54.7	1–9
Natchez, Miss.	46	(1)	(2)	52.8	9–12
Baton Rouge, La.	35	(1)	(2)	45.7	16
Donaldsonville, La.	28	(1)	(2)	35.9	16
New Orleans, La.	18	(1)	(2)	21.3	1
Cypress:					
Jefferson, Tex.	18	(1)	5	20.1	2–3
Sulphur:					
Finley, Tex.	24	(1)	6	27.4	1
	24	15	18	25.0	15–16
Ringo Crossing, Tex.	20	(1)	2	21.3	1
	20	10	13	24.4	11
Red:					
Fulton, Ark.	28	(1)	2	28.4	2
	28	15	16	28.4	16
Alexandria, La.	36	5	25	37.4	10
Ouachita:					
Camden, Ark.	30	(1)	4	32.4	2
Monroe, La.	40	(1)	29	42.3	9–11
Atchafalaya:					
Simmesport, La.	41	(1)	(2)	51.9	16
Melville, La.	37	(1)	(2)	45.9	14–16
WEST GULF DRAINAGE.					
Sabine:					
Logansport, La.	24	(1)	21	31.0	1
	24	23	26	24.4	23–25
Bon Wier, Tex.	20	5	17	20.9	10–12
Neches:					
Rockland, Tex.	20	(1)	14	27.5	5
Beaumont, Tex.	7	8	17	9.5	11
Trinity:					
Fort Worth, Tex.	30	9	9	35.1	9
Dallas, Tex.	25	(1)	5	32.9	1
	25	9	15	41.7	9
Trinidad, Tex.	28	(1)	22	39.9	15
Long Lake, Tex.	40	(1)	10	43.3	2
	40	14	23	42.0	18
Riverside, Tex.	40	3	15	46.2	4
	40	25	26	40.2	25
Liberty, Tex.	25	(1)	(2)	28.6	8–11
Brazos:					
Kopperl, Tex.	21	9	11	48.0	9
Waco, Tex.	27	10	11	36.4	10
	27	15	15	27.5	15
Valley Junction, Tex.	44	2	6	47.0	3
Washington, Tex.	45	(1)	15	50.9	5
Hempstead, Tex.	40	2	11	43.6	6
	40	14	15	40.7	15
Rosenberg, Tex.	43	5	14	49.8	9
Freeport, Tex.	4	1	1	4.2	1
	4	10	15	4.7	13
Colorado:					
Austin, Tex.	18	(1)	4	23.0	2
Columbus, Tex.	28	(1)	10	38.2	4–5
	28	21	22	29.0	21
Smithville, Tex.	24	(1)	6	28.2	3
Guadalupe:					
Gonzales, Tex.	22	4	5	30.3	4
Victoria, Tex.	16	(1)	9	23.2	8
Rio Grande:					
Rio Grande City, Tex.	15	2	2	19.5	2
COLORADO DRAINAGE.					
Eagle:					
Eagle, Colo.	5	29	29	5.0	29
Gunnison:					
Sapinero, Colo.	16	6	8	17.0	7
	16	24	(2)	17.6	28
Delta, Colo.	9	7	8	9.1	7
North Fork of Gunnison:					
Paonia, Colo.	8	(1)	(2)	9.5	30
Green:					
Elgin, Utah.	13	28	(2)	13.3	31
Colorado:					
Fruita, Colo.	12	27	(2)	12.3	29
Lees Ferry, Ariz.	12	(1)	(2)	22.3	31
Topock, Ariz.	14	8	8	14.1	8
	14	10	15	16.8	13
Parker, Ariz.	14	26	(2)	18.5	31
	7	5	(2)	10.3	31
PACIFIC DRAINAGE.					
Kings:					
Piedra, Calif.	12	6	8	12.7	7
	12	18	19	12.7	19
	12	23	(2)	13.4	31
Columbia:					
Marcus, Wash.	24	31	(2)	24.0	31
Vancouver, Wash.	15	21	(2)	18.1	30–31
Clearwater:					
Kamiah, Idaho.	14	19	19	14.2	19
Willamette:					
Portland, Oreg.	15	21	(2)	17.4	30–31

[1] Continued from April, 1922.
[2] Continued into June, 1922.

MEAN LAKE LEVELS DURING MAY, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., June 5, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Mean level during May, 1922:				
Above mean sea level at New York	601.94	580.40	572.74	246.55
Above or below—				
Mean stage of April, 1922	+0.49	+0.47	+0.39	+0.49
Mean stage of May, 1921	−0.18	−0.18	−0.35	−0.13
Average stage for May, last 10 years	−0.20	−0.29	−0.08	−0.17
Highest recorded May stage	−1.11	−3.12	−1.68	−2.40
Lowest recorded May stage	+1.12	+0.84	+1.43	+1.59
Average relation of the May level to:				
April level		+0.30	+0.40	+0.30
June level		−0.10	−0.20	−0.20

[1] Lake St. Clair's level: In May, 575.25 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, MAY, 1922.

By J. WARREN SMITH, Meteorologist.

May was warmer than normal in all districts except in the Rocky Mountain States and in a small area in the Southeast covering northern Georgia and southeastern Alabama and in extreme southern Florida. The temperature averaged 5° or more a day above the normal in most of the Lake region. During the week ending May 9 the temperature averaged above the normal except in Washington, Oregon, northern Idaho, and western Montana. Freezing occurred from Nevada northward with frost in adjoining districts.

Freezing weather prevailed during the first part of the succeeding week between the Rocky Mountains and the Sierra Nevada and Cascade ranges, with the temperature down to 20° at Flagstaff, Ariz., on the 10th and at Modena, Utah, on the 11th. It was very cold and stormy in the Rocky Mountain and Plateau States and considerable frost damage occurred, although the season was unusually backward. The week continued warmer than normal from the eastern Great Plains eastward. The third week of the month was slightly warmer than normal over the Rocky Mountain and Plateau States and in most of the North, but it was slightly colder in most central and southeastern districts. During the week ending May 30 the temperature averaged above the normal, except in a few southeastern and far northwestern areas. Frost caused moderate damage in the far Northwest on May 26 or 27.

The rainfall for the month, as a whole, was above the normal in central and southern New England, in parts of the central Ohio and central Upper Mississippi Valleys, in most of the south, and in the upper Great Plains. It was below the normal in the Lake region, part of the Middle Atlantic coast, in the lower Ohio and central Mississippi Valleys, the central Great Plains, central and upper Rocky Mountains, and most of the Pacific coast region. The rainfall was over 6 inches in most of the South, in south-central Iowa, and over small areas in west-central Ohio and eastern Montana.

During the week ending May 9 the rainfall was moderate to heavy and rather uniformly distributed east of the 100th meridian. The falls were excessive locally in the lower Mississippi Valley, the central Great Plains, parts of Texas, and along the New England coast. In the week ending the 16th the precipitation was rather heavy in most of the northern Great Plains, along the west Gulf coast, and in parts of Georgia and Kentucky. Snow fell in the upper Great Plains during the storm of the 11th. Heavy to excessive rains fell in the central Great Plains and in many southern districts during the week ending the 23d, and from the lower Mississippi Valley eastward and in parts of the upper Mississippi Valley during the last week of the month. Generous precipitation was received also in northern Idaho, western South Dakota, and much of Montana, being in the form of snow in the northern Rockies.

At the close of the month drought conditions prevailed in western Iowa, southeastern South Dakota, and northeastern Nebraska, as well as in western New Mexico and eastern Arizona. More moisture was needed in the Northeast and in the unirrigated districts of the far West, but there was ample moisture for crop needs in most Central and Eastern States. Flood waters covered large areas of agricultural land in the lower Mississippi Valley during most of the month.

Winter wheat improved under favorable weather conditions in the Northeast and in Montana, but it was too wet and warm in much of the South where rust developed. There was a lack of moisture in some central valley States, and it was too dry and cool in the far Northwest.

Conditions for seeding spring-wheat improved early in the month, the seed germinated quickly, and the prevailing moisture and temperature were favorable for satisfactory development, except in the North Pacific Coast States.

Oats were seeded late in central districts, and there was a lack of moisture in parts of the central Mississippi and lower Missouri Valley States. The crop was in a fairly satisfactory condition at the close of the month in most northern States. The first part of the month was rather unfavorable for the preparation of the ground and planting corn in the Ohio Valley and the Southwest, while cultivation was hindered by rain in some southern districts throughout the month. The temperature was favorable for germination and growth with few exceptions.

Slow progress was made in planting and replanting cotton during the first week in May due to general rains and wet soil. The week ending May 16 was more favorable in the central and eastern portions of the belt, but it continued unfavorable in Oklahoma and much of Texas. The moderate to heavy rains during the week ending May 23 in central and eastern portions of the belt were unfavorable and the nights were too cool for proper germination and growth. Better weather prevailed in the western portion of the belt during the last week in the month, but it was too wet and the latter part of the week too cool in the east Gulf States for satisfactory growth of cotton.

At the close of the month cotton was in fairly good condition in the northern part of the belt and in the extreme southeastern districts, but it was unsatisfactory in central and southwestern regions.

Cold and stormy weather in the Northwest at the beginning of the second decade was decidedly unfavorable for stock and some losses occurred. Pastures made good advance during the month, but meadows were unfavorably affected by a lack of moisture in parts of the middle Atlantic coast, the lower Ohio Valley, the central Mississippi and the lower Missouri Valleys, and the far West.

CLIMATOLOGICAL TABLES.[1]

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, May, 1922.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	72.0	+0.5	Selma	97	9	Riverton	45	1	6.70	+2.63	Robertsdale	11.71	Birmingham	3.42
Arizona	67.3	+1.8	Maricopa	112	30	Fort Valley	17	10	0.38	+0.05	Spring Valley	2.40	10 stations	0.00
Arkansas	70.8	+1.6	Texarkana	100	11	3 stations	40	[2]1	5.00	−0.12	Huttig	12.69	Corning	1.57
California	62.1	+0.7	Greenland Ranch	111	24	2 stations	10	10	1.13	+0.04	Tamarack	5.47	4 stations	0.00
Colorado	51.6	+0.3	Lamar	91	5	Silverton	2	12	1.41	−0.41	Yuma	4.67	Saguache	T.
Florida	76.4	+0.9	4 stations	99	[2]14	DeFuniak Springs	50	[2]18	7.42	+3.16	Davie	12.33	Fort Pierce	2.54
Georgia	72.0	0.0	Quitman	99	13	Blue Ridge	40	1	7.18	+3.79	Clayton	12.23	Lumber City	4.47
Hawaii	71.5	−0.1	Mahukona	91	11	Volcano Observatory	49	[2]7	4.11	−1.80	Eke	20.50	8 stations	0.00
Idaho	51.7	−0.5	Glenns Ferry	93	24	2 stations	10	[2]10	1.30	−0.49	Musselshell, R. S.	3.23	Lifton	0.20
Illinois	66.5	+3.8	5 stations	91	[2]10	Freeport	36	[2]1	3.59	−0.64	Palestine	8.77	Mount Vernon	1.14
Indiana	66.6	+4.3	4 stations	92	[2]11	La Porte	35	1	3.62	−0.50	Auburn	8.19	Kokomo	1.52
Iowa	63.4	+2.9	Cedar Rapids	91	10	2 stations	34	[2]7	3.53	−1.04	Ames	8.36	Algona	0.47
Kansas	64.6	+1.2	Chanute	92	21	3 stations	33	[2]12	4.06	+0.04	Winfield	9.81	Elkhart	0.90
Kentucky	67.9	+2.3	Bowling Green	94	11	Marion	35	1	3.87	−0.08	Beaver Dam	9.39	Frankfort	1.50
Louisiana	75.0	+1.2	Jeanerette	97	12	Calhoun	46	1	6.81	+2.45	Avoca Island	13.09	Newellton	2.50
Maryland-Delaware	64.7	+1.8	Hancock, Md	93	11	Oakland, Md	25	1	3.08	−0.48	State Sanatorium, Md.	5.40	Milford, Del	1.19
Michigan	59.6	+5.9	Harrison	93	11	Mancelona	25	8	2.96	−0.38	Coldwater	6.92	Gaylord	1.25
Minnesota	60.2	+5.9	Morris	94	28	Morris	26	12	3.07	−0.35	Crookston	6.65	Fairmont	1.29
Mississippi	72.7	+1.1	Shubuta	95	11	Duck Hill	47	1	5.88	+1.34	Leakesville	12.36	Utica	2.70
Missouri	67.2	+2.3	Caruthersville	97	26	2 stations	38	[2]1	3.17	−1.77	Oregon	6.86	Poplar Bluff	1.01
Montana	50.5	−0.3	Billings	96	25	Trout Creek	18	9	2.40	+0.03	Sentinel Butte Pass.	7.07	Libby	0.64
Nebraska	60.3	+1.2	2 stations	92	[2]5	Harrison	26	12	2.77	−0.82	Cairo	6.18	O'Neill	1.05
Nevada	56.5	+0.3	Logandale	104	27	Rye Patch	15	[2]11	0.70	−0.29	Owyhee	2.42	2 stations	T.
New England	57.1	+2.3	Waterbury, Conn	92	31	2 stations	19	1	4.13	+0.82	Torrington, Conn	6.60	Orono, Me	1.05
New Jersey	63.0	+2.6	2 stations	90	[2]26	Charlotteburg	23	1	3.84	+0.04	Newark	7.55	Northfield	1.16
New Mexico	59.9	+0.6	4 stations	99	[2]5	Virsylvia	11	12	1.04	−0.19	Diener	4.05	15 stations	0.00
New York	59.2	+3.1	Andover	93	24	Indian Lake	19	1	3.32	−0.36	Bedford Hills	6.65	Moira	0.89
North Carolina	67.2	+0.4	Wenona	94	12	2 stations	29	1	5.07	+1.04	Marion	11.01	Belhaven	1.40
North Dakota	55.3	+3.7	2 stations	93	[2]24	Arnegard	24	3	3.11	+0.56	Jamestown	6.82	Powers Lake	1.23
Ohio	64.0	+3.3	Green	96	11	Madison	27	1	4.69	+1.11	Findlay	9.39	Fernbank	1.87
Oklahoma	69.1	+1.4	Mangum	100	20	Kenton	34	12	5.72	+0.56	Newkirk	10.42	Beaver	1.16
Oregon	54.0	+0.7	2 stations	100	[2]30	Crater Lake	10	26	1.29	−0.75	Astoria	5.38	2 stations	T.
Pennsylvania	62.5	+2.7	Beaver Dam	96	25	West Bingham	20	1	3.21	−0.54	Williamsport	6.10	Altoona	1.69
South Carolina	71.0	−0.2	Garnett	98	13	Calhoun Falls	38	1	5.89	+2.31	Georgetown	12.65	Heath Springs	2.63
South Dakota	57.9	+2.7	Alexandria	90	10	Kennebec	23	19	3.59	−0.05	Deadwood	13.75	Menno	0.80
Tennessee	68.5	+1.5	4 stations	92	[2]9	Mountain City	31	1	4.84	+0.57	Lebanon	8.32	Rogersville	2.37
Texas	75.0	+2.0	Encinal	105	[2]21	Clint	33	12	4.46	+1.14	Brazos	12.90	O 2 Ranch	T.
Utah	54.6	+0.2	St. George	99	23	Price	3	11	1.23	+0.02	Hiawatha	3.43	New Harmony	0.00
Virginia	65.3	+1.0	Danville	92	12	Pulaski	32	1	4.17	+0.38	Clarksville	8.24	Cape Henry	1.83
Washington	53.8	−0.7	Wheeler	98	18	Colfax	16	9	1.24	−0.74	Cedar Lake	8.05	4 stations	0.00
West Virginia	63.7	+1.8	2 stations	94	[2]23	2 stations	26	1	3.67	−0.22	Elizabeth	5.83	Upper Tract	1.55
Wisconsin	60.9	+6.1	Waupaca	92	[2]10	Grantsburg	29	31	3.53	−0.40	Beloit	7.55	Marinette	1.47
Wyoming	48.8	+0.3	Gillette	92	26	Bow Ranger	6	11	2.18	−0.04	Knowles	9.23	Hyattville	0.11

[1] For description of tables and charts, see REVIEW, Jan. 1921, p. 41.

[2] Other dates also.

TABLE I.—*Climatological data for Weather Bureau stations, May, 1922.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F*		*° F*	*° F.*		*° F*	*° F.*	*° F.*	*° F.*	*%*	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
New England.							**57.6**	**+3.1**										**72**	**4.12**	**+0.8**										**4.3**		
Eastport	76	67	85	29.91	29.99	+.03	49.8	+2.9	84	29	58	32	1	41	32	45	41	75	2.27	−1.5	11	7,503	s.	35	e.	6	11	6	14	5.7	0.0	0.0
Greenville, Me	1,070	6	....	28.84	30.00	.....	52.6	.....	81	31	64	25	1	41	42	.....	.....	.....	3.44	.....	10	.....	.....	.....	.....	.....	16	6	9	....	0.0	0.0
Portland, Me	103	82	117	29.90	30.02	+.05	55.8	+2.5	87	29	64	38	5	47	36	49	42	64	5.72	+2.0	8	7,741	nw.	35	se.	19	14	9	8	4.3	0.0	0.0
Concord	288	70	79	29.70	30.01	+.03	58.5	+2.8	85	29	71	28	1	46	41	.....	.....	.....	5.30	+2.1	6	4,295	n.	31	s.	19	23	3	15	3.2	0.0	0.0
Burlington	404	11	48	29.58	30.01	+.04	57.5	+3.6	83	29	68	30	1	47	38	.....	.....	.....	2.22	−0.6	7	7,579	n.	42	s.	4	14	6	11	4.5	0.0	0.0
Northfield	876	12	60	29.07	30.02	+.05	54.4	+0.9	83	30	68	24	1	40	47	51	48	74	2.51	−0.3	8	5,580	s.	34	s.	19	11	11	9	5.3	0.0	0.0
Boston	125	115	188	29.87	30.00	+.02	61.4	+4.3	86	29	71	43	4	52	31	55	49	68	5.34	+1.8	4	7,648	w.	36	sw.	19	13	13	5	3.9	0.0	0.0
Nantucket	12	14	90	30.00	30.01	+.02	55.6	+2.6	76	30	63	40	1	48	25	51	48	82	3.44	+0.8	8	12,048	sw.	45	se.	5	12	12	7	4.6	0.0	0.0
Block Island	26	11	46	29.96	29.99	.00	55.6	+2.7	72	26	62	42	1	49	25	52	50	88	4.17	+0.4	7	12,395	sw.	40	ne.	27	16	9	6	3.6	0.0	0.0
Providence	160	215	251	29.83	30.00	+.02	61.6	+3.1	86	30	72	39	1	51	30	53	46	61	4.24	+0.8	6	8,853	nw.	48	nw.	11	12	15	4	4.2	0.0	0.0
Hartford	159	122	140	29.83	30.01	+.03	62.2	+4.7	86	30	74	39	1	51	31	55	50	69	5.42	+1.9	8	5,862	s.	32	sw.	7	15	9	7	4.4	0.0	0.0
New Haven	106	74	153	29.89	30.00	+.01	61.6	+4.0	83	29	72	40	1	52	31	54	47	65	4.65	+1.0	6	7,280	sw.	32	nw.	11	16	11	4	3.5	0.0	0.0
Middle Atlantic States.							**64.4**	**+2.7**										**70**	**3.15**	**−0.3**										**4.9**		
Albany	97	102	115	29.89	29.99	+.01	62.2	+3.3	85	30	74	34	1	51	35	54	47	62	3.68	+0.7	7	5,452	s.	42	s.	19	19	8	4	3.2	0.0	0.0
Binghamton	871	10	84	29.08	30.00	+.02	60.8	+3.8	85	30	73	29	1	48	41	.....	.....	.....	2.35	−0.7	8	3,978	nw.	26	w.	7	15	7	9	4.6	0.0	0.0
New York	314	414	454	29.67	30.00	+.01	63.6	+5.3	83	26	72	44	1	55	26	54	48	63	3.24	+0.1	9	9,617	sw.	60	nw.	11	12	13	6	4.7	0.0	0.0
Harrisburg	374	94	104	29.60	30.00	+.02	65.0	+3.3	88	11	75	41	1	55	30	57	50	63	3.72	0.0	11	4,421	s.	30	sw.	7	10	13	8	5.3	0.0	0.0
Philadelphia	117	123	190	29.89	30.01	+.02	66.4	+4.2	85	11	76	47	1	57	28	57	51	63	2.47	−0.7	10	7,519	sw.	36	sw.	19	11	11	9	5.2	0.0	0.0
Reading	325	81	98	29.64	29.98	.....	65.1	.....	85	11	76	38	1	55	33	57	51	65	3.23	−0.1	12	3,892	se.	26	sw.	19	10	14	7	5.1	0.0	0.0
Scranton	805	111	119	29.15	30.00	+.02	62.2	+3.4	87	24	74	33	1	51	38	55	49	65	2.20	−1.2	9	4,802	n.	31	sw.	7	7	16	8	5.5	0.0	0.0
Atlantic City	52	37	172	29.95	30.01	+.03	61.2	+3.1	86	11	67	41	1	55	30	57	54	80	1.45	−1.6	8	12,919	s.	52	e.	27	16	8	7	3.9	0.0	0.0
Cape May	18	13	49	30.02	30.04	+.05	62.6	+4.0	83	11	70	42	1	55	23	57	54	80	1.23	−1.8	11	6,241	s.	38	ne.	27	15	7	9	4.4	0.0	0.0
Sandy Hook	22	10	55	29.98	30.00	.....	61.8	.....	85	26	70	43	1	54	27	55	52	77	3.27	.....	8	9,814	s.	46	s.	19	14	11	6	4.3	0.0	0.0
Trenton	190	159	183	29.80	30.00	.....	64.2	.....	84	30	75	39	1	53	31	58	54	72	3.03	−0.5	7	8,299	sw.	40	sw.	19	9	13	9	5.4	0.0	0.0
Baltimore	123	100	113	29.86	30.00	+.01	67.2	+3.0	89	11	76	46	1	58	30	59	53	66	4.00	+0.4	11	4,502	s.	30	sw.	19	12	9	10	5.1	0.0	0.0
Washington	112	62	85	29.87	29.99	−.01	66.8	+2.6	88	11	77	41	1	56	31	59	53	65	4.27	+0.4	11	4,264	sw.	24	sw.	19	11	9	11	5.5	0.0	0.0
Lynchburg	681	153	188	29.26	30.00	.00	67.2	−0.1	89	11	78	41	1	56	32	60	56	72	4.37	+0.4	12	4,854	e.	36	e.	27	10	12	9	5.6	0.0	0.0
Norfolk	91	170	205	29.91	30.01	+.01	67.9	+1.7	85	21	77	47	1	59	25	60	56	71	3.42	−0.6	12	8,751	se.	44	ne.	27	8	13	10	5.7	0.0	0.0
Richmond	144	11	52	29.85	30.00	+.01	67.2	−0.1	87	11	78	42	1	57	30	60	56	73	3.27	−0.6	12	5,080	sw.	32	sw.	18	13	9	9	4.7	0.0	0.0
Wytheville	2,304	49	56	27.66	30.00	+.01	61.5	+0.1	84	9	72	38	1	51	34	56	52	77	4.53	+0.6	14	3,983	w.	36	w.	19	13	9	9	4.8	0.0	0.0
South Atlantic States.							**70.9**	**+0.9**										**77**	**5.65**	**+1.9**										**5.9**		
Asheville	2,255	70	84	27.68	29.99	.00	63.2	+0.6	83	9	73	36	1	54	32	57	53	74	2.59	−1.2	13	5,151	se.	32	nw.	18	6	16	9	6.0	0.0	0.0
Charlotte	779	55	62	29.16	29.98	−.01	69.4	+1.0	88	11	79	49	1	60	26	62	58	72	3.72	−0.2	12	3,362	se.	20	sw.	19	9	10	12	6.0	0.0	0.0
Hatteras	11	11	50	29.98	29.99	.00	68.5	+1.4	81	22	74	54	1	63	19	65	63	80	8.32	+4.2	9	9,678	sw.	44	ne.	27	8	15	8	5.3	0.0	0.0
Manteo	12	5	42	.....	.....	.....	67.0	.....	84	10	76	44	1	59	20	.....	.....	.....	3.36	.....	8	.....	sw.	.....	.....	.....	16	3	12	....	0.0	0.0
Raleigh	376	103	110	29.59	29.98	−.01	69.0	−0.1	90	12	79	46	1	59	29	62	58	73	4.05	−0.8	14	5,512	sw.	35	w.	19	10	10	11	5.5	0.0	0.0
Wilmington	78	81	91	29.92	30.00	−.01	70.5	+1.4	89	11	79	49	29	62	25	65	63	81	5.20	+1.2	11	5,964	sw.	28	sw.	19	9	12	10	5.4	0.0	0.0
Charleston	48	11	92	29.93	29.98	−.03	73.6	+0.9	93	13	80	58	29	67	21	68	65	79	9.56	+6.1	16	8,319	ne.	34	e.	30	9	11	11	5.5	0.0	0.0
Columbia, S. C	351	41	57	29.62	29.99	+.01	71.7	−0.1	90	11	81	51	1	63	24	64	60	74	2.85	−0.3	10	4,811	ne.	25	ne.	28	9	5	17	6.0	0.0	0.0
Greenville, S. C	1,039	113	122	28.89	29.97	.....	68.6	.....	85	13	78	49	1	60	26	62	58	72	6.28	.....	13	6,050	ne.	34	w.	19	7	12	12	6.0	0.0	0.0
Augusta	180	62	77	29.78	29.97	−.02	72.5	+0.1	91	11	81	54	1	64	26	66	64	78	5.16	+1.9	13	4,168	e.	24	ne.	28	6	12	13	6.4	0.0	0.0
Savannah	65	150	194	29.90	29.97	−.03	74.3	+1.8	94	13	82	57	1	66	25	68	66	82	7.86	+4.9	16	9,086	e.	45	w.	17	6	12	13	6.4	0.0	0.0
Jacksonville	43	209	245	29.92	29.97	−.03	76.4	+2.2	93	13	84	62	18	69	22	69	66	77	7.18	+2.9	13	8,747	ne.	45	w.	17	11	11	9	5.4	0.0	0.0
Due West	711	10	55	29.25	30.01	.....	69.3	.....	88	11	78	50	1	60	28	.....	.....	.....	4.59	.....	17	6,102	e.	39	n.	13	7	7	17	6.7	0.0	0.0
Florida Peninsula.							**78.3**	**−0.2**										**78**	**5.82**	**+1.6**										**6.2**		
Key West	22	10	64	29.93	29.94	−.03	79.4	+0.3	88	17	84	69	29	74	16	73	71	77	5.01	+1.6	15	7,327	se.	46	nw	5	6	13	12	6.1	0.0	0.0
Miami	25	71	79	29.95	29.98	.....	77.2	−1.4	89	14	83	68	19	71	21	72	70	77	9.06	+2.7	18	5,657	e.	38	nw.	30	4	10	17	7.0	0.0	0.0
Sand Key	23	39	72	29.94	29.97	.00	77.2	.....	83	15	80	69	8	74	10	73	71	80	4.91	.....	14	9,186	se.	42	sw.	18	9	11	11	6.0	0.0	0.0
Tampa	35	79	92	29.92	29.96	−.03	78.2	+1.8	93	14	87	64	19	70	24	70	68	76	3.40	+0.5	10	5,114	ne.	27	ne.	23	8	12	11	5.9	0.0	0.0
East Gulf States.							**72.7**	**+0.5**										**79**	**6.37**	**+2.9**										**6.5**		
Atlanta	1,174	190	216	28.76	29.99	.00	69.0	−0.9	85	8	77	53	1	61	22	63	60	78	8.01	+4.9	17	8,246	e.	48	nw.	6	4	7	20	7.2	0.0	0.0
Macon	370	78	87	29.58	29.97	−.02	72.0	+0.9	91	11	81	53	29	63	28	65	61	75	5.89	+3.0	14	4,600	e.	29	nw.	4	5	12	14	6.6	0.0	0.0
Thomasville	273	49	58	29.66	29.95	−.04	75.3	+1.3	93	11	85	57	1	66	28	67	64	76	8.21	+4.2	16	3,443	sw.	25	ne.	28	2	16	13	7.2	0.0	0.0
Pensacola	56	149	185	29.88	29.94	−.05	73.4	−0.5	90	12	78	58	1	68	22	70	68	85	9.74	+7.1	14	9,192	s.	41	e.	29	10	8	13	6.1	0.0	0.0
Anniston	741	9	57	29.20	29.98	−.01	70.2	+1.8	89	9	80	53	14	60	29	.....	.....	.....	5.28	+2.2	18	3,775	e.	24	nw.	6	7	14	10	5.8	0.0	0.0
Birmingham	700	11	48	29.22	29.98	.00	71.6	0.0	89	24	81	52	1	62	26	64	61	76	3.42	+0.3	16	4,505	e.	35	se.	20	3	14	14	6.9	0.0	0.0
Mobile	57	125	161	29.88	29.94	−.05	74.1	+0.5	91	12	81	55	1	67	26	69	67	83	8.31	+4.3	13	6,647	sw,	34	w.	4	1	20	10	6.8	0.0	0.0
Montgomery	223	100	112	29.72	29.96	−.03	73.6	+0.1	90	12	82	58	18	65	24	66	63	76	5.89	+2.1	20	4,570	se.	25	e.	28	9	7	15	6.5	0.0	0.0
Corinth	469	6	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Meridian	375	85	93	29.55	29.94	−.04	72.3	+1.2	89	7	82	54	1	63	26	66	63	78	5.37	+1.4	16	3,778	sw.	31	nw.	12	5	13	13	6.7	0.0	0.0
Vicksburg	247	65	73	29.67	29.94	−.03	73.0	+0.1	87	27	81	57	1	65	23	67	65	83	4.24	0.0	13	4,428	se.	49	nw.	20	5	17	9	6.1	0.0	0.0
New Orleans	53	76	84	29.88	29.93	−.04	75.7	+1.2	90	12	83	62	1	68	21	70	68	81	5.75	+1.9	12	4,850	se.	34	ne.	20	4	18	9	6.1	0.0	0.0
West Gulf States.							**74.8**	**+2.0**										**77**	**4.74**	**+0.7**										**5.2**		
Shreveport	249	77	93	29.65	29.91	−.04	75.3	+2.1	90	26	84	58	17	66	26	68	66	77	4.04	−0.1	10	5,291	s.	36	nw.	28	15	10	6	4.5	0.0	0.0
Bentonville	1,303	11	44	.....	.....	.....	67.8	+1.4	85	21	78	48	19	58	33	.....	.....	.....	4.32	.....	13	.....	.....	.....	.....	.....	12	11	8	....	0.0	0.0
Fort Smith	457	79	94	29.42	29.89	−.04	71.4	+1.7	89	6	80	53	17	63	30	64	61	74	2.86	−2.0	17	5,326	e.	42	w.	21	8	8	15	6.3	0.0	0.0
Little Rock	357	136	144	29.54	29.91	−.04	71.5	+1.1	87	10	80	55	19	63	28	65	61	76	4.74	−0.4	10	5,737	s.	55	w.	20	10	15	6	5.1	0.0	0.0
Brownsville	57	4	26	.....	.....	.....	81.4	.....	98	29	90	65	26	73	26	.....	.....	.....	3.90	.....	7	.....	se.	.....	.....	.....	.....	.....	.....	.....	0.0	0.0
Corpus Christi	20	11	73	29.86	29.88	−.02	79.3	+2.8	91	24	85	66	16	73	25	73	71	81	6.34	+3.6	8	10,404	se.	54	se.	9	3	21	7	5.9	0.0	0.0
Dallas	512	109	117	29.35	29.89	.....	74.5	.....	95	20	83	54	16	66	26	.....	.....	.....	6.66	.....	10	6,411	se.	39	n.	8	10	13	8	5.3	0.0	0.0
Fort Worth	670	106	114	29.16	29.87	−.03	74.1	+0.9	98	20	83	52	17	65	27	66	62	71	4.58	+0.4	8	7,146	s.	41	s.	21	11	11	9	5.1	0.0	0.0
Galveston	54	106	114	29.86	29.92	−.02	77.3	+2.2	90	27	82	62	3	72	18	73	72	86	4.93	+1.7	11	8,716	se.	48	nw.	15	8	21	2	4.7	0.0	0.0
Groesbeck	461	11	56	29.41	29.88	.....	74.8	.....	91	27	83	56	15	66	27	.....	.....	.....	6.61	.....	12	7,465	se.	45	w.	3	11	14	6	4.8	0.0	0.0
Houston	138	111	121	29.74	29.88	.....	77.6	+2.1	92	23	86	59	16	69	25	.....	.....	.....	6.07	.....	11	6,085	se.	37	se.	1	9	18	4	4.5	0.0	0.0
Palestine	510	64	72	29.38	29.90	−.03	75.1	+2.6	92	27	83	57	17	67	25	67	65	76	5.62	+ 0.7	11	5,284	s.	22	s.	10	10	9	12	5.8	0.0	0.0
Port Arthur	34	58	66	29.87	29.91	.....	76.6	.....	90	27	83	61	15	70	21	70	68	79	3.40	.....	11	7,353	se.	48	nw.	15	9	15	7	4.8	0.0	0.0
San Antonio	701	119	132	29.16	29.87	−.03	77.0	+2.4	97	28	87	57	17	67	33	68	64	72	3.46	+0.5	11	5,280	s.	46	se.	14	9	16	6	5.4	0.0	0.0
Taylor	582	55	63	29.30	29.91	.00	76.0	+2.7	93	28	85	56	16	67	28	.....	.....	.....	6.10	+2.1	10	6,414	se.	37	se.	12	7	12	12	5.8	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, May, 1922*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F.*	° *F.*		° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*N*	*In.*	*In.*		*Miles.*							*0–10*	*In.*	*In.*
Ohio Valley and Tennessee.																																
							67.6	+2.7												69	3.42	−0.3									5.8		
Chattanooga	762	189	213	29.17	29.97	−.02	69.2	+0.6	86	9	78	49	1	60	28	61	58	73	4.21	+0.6	18	4,823	sw.	33	nw.	18	3	16	12	6.5	0.0	0.0
Knoxville	996	102	111	28.94	29.98	−.01	68.2	+1.7	88	9	78	46	1	58	31	61	57	72	3.82	+0.1	15	3,967	ne.	30	sw.	19	1	11	19	7.7	0.0	0.0
Memphis	399	76	97	29.55	29.97	+.01	72.4	+1.7	87	10	80	58	1	65	22	64	60	69	3.48	−0.9	12	4,421	s.	38	nw.	13	8	10	13	5.8	0.0	0.0
Nashville	546	168	191	29.40	29.97	−.01	69.9	+1.1	88	10	79	49	1	61	30	62	59	73	4.39	+0.9	12	5,570	se.	38	ne.	27	7	10	14	6.3	0.0	0.0
Lexington	989	193	230	28.92	29.97	−.02	68.4	+4.1	87	9	77	52	20	60	25				3.10	−0.4	13	8,611	sw.	40	w.	18	12	9	10	5.1	0.0	0.0
Louisville	525	219	255	29.39	29.97	−.01	69.3	+2.6	88	11	78	50	1	60	25	61	56	65	2.17	−1.5	10	6,480	s.	36	s.	6	12	11	8	4.7	0.0	0.0
Evansville	431	139	175	29.50	29.96	−.01	70.4	+3.3	88	31	80	53	1	61	25	61	56	65	2.69	−0.7	9	7,102	sw.	40	w.	22	7	19	5	5.9	0.0	0.0
Indianapolis	822	194	230	29.08	29.96	−.01	67.5	+4.2	86	11	76	51	19	58	26	59	54	65	2.58	−1.4	12	7,824	s.	34	ne.	26	9	12	10	5.8	0.0	0.0
Royal Center	739	11	55	29.16	29.95	.....	64.2	.....	86	11	75	46	14	54	32	.....	.....	.....	3.12	.....	15	6,726	e.	30	w.	6	5	9	17	6.3	0.0	0.0
Terra Haute	575	96	129	29.32	29.93	.....	68.2	.....	86	11	78	51	1	59	29	61	57	71	2.65	.....	10	6,265	se.	36	w.	18	6	14	11	6.1	0.0	0.0
Cincinnati	628	11	51	29.30	29.97	−.02	66.8	+3.7	87	9	77	48	1	57	32	.....	56	69	2.09	−1.4	11	4,272	sw.	26	sw.	19	9	12	10	5.5	0.0	0.0
Columbus	824	179	222	29.11	29.97	−.01	65.6	+3.3	86	9	74	49	1	57	31	59	54	70	5.26	+1.5	12	6,454	se.	38	w.	18	9	16	6	4.9	0.0	0.0
Dayton	899	181	216	28.99	29.93	.....	66.4	+3.5	86	24	76	48	1	57	27	59	54	69	4.16	+0.3	17	6,134	ne.	34	w.	19	12	12	7	4.6	0.0	0.0
Elkins	1,947	59	67	27.98	30.00	.00	61.4	+2.3	84	24	73	34	1	49	40	55	51	73	3.25	−0.7	14	3,056	nw.	29	sw.	19	8	8	15	6.4	0.0	0.0
Parkersburg	638	77	84	29.34	30.00	+.01	66.0	+2.5	89	24	76	42	1	56	37	58	54	71	4.09	+0.6	16	3,070	se.	22	se.	16	9	8	14	5.8	0.0	0.0
Pittsburgh	842	353	410	29.09	29.98	−.01	65.0	+2.6	88	24	74	40	1	55	34	57	52	67	2.59	−0.7	11	6,367	nw.	39	nw.	7	10	8	13	5.6	0.0	0.0
Lower Lake Region.																																
							61.1	+3.6												70	2.39	−0.8									4.7		
Buffalo	767	247	280	29.16	29.99	+.02	60.2	+5.7	88	24	69	43	1	52	35	54	50	74	2.01	−1.1	11	8,932	sw.	58	sw.	7	12	7	12	5.5	0.0	0.0
Canton	448	10	61	29.50	29.98	.....	58.5	+2.3	84	31	69	37	12	48	34	.....	.....	.....	1.19	−1.7	6	7,106	sw.	39	w.	7	21	3	7	3.0	0.0	0.0
Oswego	335	76	91	.....	29.99	+.02	56.8	+2.1	83	31	65	36	1	48	32	.....	.....	68	1.71	−1.1	9	.....	se.	29	sw.	7	14	5	12	.....	0.0	0.0
Rochester	523	86	102	29.43	30.00	+.03	61.0	+3.9	87	31	71	37	1	51	35	53	46	59	1.35	−1.6	9	5,216	sw.	34	w.	7	15	5	11	4.7	0.0	0.0
Syracuse	597	97	113	29.37	30.02	+.04	60.2	+3.3	86	31	69	33	1	53	36	54	49	66	1.98	−1.4	7	8,101	nw.	46	sw.	7	14	10	7	4.2	0.0	0.0
Erie	714	130	166	29.21	29.98	.00	61.2	+2.9	82	24	70	34	1	50	32	.....	.....	.....	3.84	+0.4	7	6,865	s.	38	sw.	7	16	6	9	4.5	0.0	0.0
Cleveland	762	190	201	29.16	29.98	.00	61.3	+2.8	82	31	68	44	1	54	21	55	50	69	2.42	−0.8	10	7,087	ne.	39	sw.	6	13	9	9	5.1	0.0	0.0
Sandusky	629	62	103	29.30	29.98	.00	62.2	+3.0	84	31	69	43	1	55	24	.....	.....	.....	2.58	−0.7	11	6,734	e.	44	nw.	6	12	9	10	4.8	0.0	0.0
Toledo	628	208	243	29.30	29.97	.00	63.2	+3.8	84	31	72	43	1	55	28	58	54	76	4.29	+1.0	13	8,035	sw.	43	sw.	6	14	6	11	4.7	0.0	0.0
Fort Wayne	856	113	124	29.05	29.97	.....	64.6	+4.4	86	11	74	41	1	55	32	58	54	74	3.84	.....	12	5,470	e.	36	s.	6	10	9	12	5.6	0.0	0.0
Detroit	730	218	245	29.19	29.98	+.01	62.8	+4.9	85	11	72	45	1	54	26	56	51	70	2.53	−0.7	10	6,285	ne.	35	w.	6	14	8	9	4.6	0.0	0.0
Upper Lake Region.																																
							58.8	+6.0												72	2.53	−0.9									5.1		
Alpena	609	13	92	29.32	29.99	+.02	55.9	+6.4	79	11	64	39	8	48	33	51	46	72	1.76	−1.6	11	6,546	se.	48	nw.	7	12	8	11	5.1	0.0	0.0
Escanaba	612	54	60	29.30	29.96	−.01	55.9	+5.9	76	25	63	43	1	48	23	51	47	76	2.35	−1.1	13	6,443	s.	27	ne.	29	14	9	8	4.3	0.0	0.0
Grand Haven	632	54	89	29.27	29.94	−.02	60.6	+5.8	82	11	70	43	1	51	28	55	51	71	2.10	−1.2	11	6,256	e.	39	w.	6	11	11	9	4.6	0.0	0.0
Grand Rapids	707	70	87	29.20	29.96	−.01	64.0	+5.0	89	11	75	46	1	53	29	56	50	63	2.64	−0.7	12	3,803	e.	26	w.	6	10	7	14	5.9	0.0	0.0
Houghton	684	62	99	29.23	29.96	−.01	57.6	+7.9	84	10	68	41	7	47	34	.....	.....	.....	2.13	−1.2	13	6,605	e.	27	e.	26	11	9	11	5.2	0.0	0.0
Lansing	878	11	62	29.02	29.96	.....	62.6	+4.7	87	11	75	40	8	51	34	56	52	73	3.39	−0.2	13	3,497	se.	21	nw.	7	10	10	11	5.7	0.0	0.0
Ludington	637	60	66	29.26	29.95	.....	58.6	.....	81	26	68	43	31	50	29	55	52	78	3.02	.....	14	5,727	s.	26	s.	6	16	9	6	4.1	0.0	0.0
Marquette	734	77	111	29.19	30.00	+.03	54.9	+5.0	83	10	64	40	30	46	37	50	46	73	3.27	0.0	11	4,685	e.	22	sw.	4	9	8	14	5.8	0.0	0.0
Port Huron	638	70	120	29.28	29.97	.00	59.3	+5.6	84	11	69	39	1	50	31	54	49	74	2.82	−0.4	11	6,205	ne.	40	nw.	7	13	9	9	4.6	0.0	0.0
Saginaw	641	69	77	29.28	29.97	.....	62.6	.....	88	11	73	42	1	52	31	55	49	65	1.56	−2.6	10	5,267	ne.	30	sw.	6	11	9	11	5.1	0.0	0.0
Sault Ste. Marie	614	11	52	29.30	30.00	+.05	57.0	+9.3	84	11	69	34	8	45	36	50	45	72	2.79	−0.5	11	4,602	se.	28	n.	7	9	13	9	5.0	0.0	0.0
Chicago	823	140	310	29.08	29.96	.00	63.8	+5.3	83	30	70	52	7	58	24	56	51	68	3.18	−0.2	13	7,290	s.	30	s.	6	10	12	9	5.2	0.0	0.0
Green Bay	617	109	144	29.28	29.94	−.01	61.8	+7.4	88	11	71	47	1	53	28	55	50	69	1.79	−1.8	10	7,639	se.	36	w.	6	9	12	10	5.8	0.0	0.0
Milwaukee	681	125	139	29.22	29.95	−.01	59.3	+5.7	82	12	67	48	14	52	27	52	48	71	2.36	−1.1	13	5,746	ne.	28	sw.	6	11	8	12	5.4	0.0	0.0
Duluth	1,133	11	47	28.73	29.95	−.01	51.4	+4.1	81	28	60	37	13	43	35	48	44	79	3.28	−0.2	9	8,173	ne.	39	nw.	4	10	9	12	5.4	0.0	0.0
North Dakota.																																
							57.3	+3.2												68	2.98	+0.5									6.5		
Moorhead	940	50	58	28.88	29.88	−.06	59.5	+4.7	81	27	70	40	4	50	30	53	48	69	3.94	+1.0	13	6,280	s.	30	nw.	3	4	13	14	6.8	0.0	0.0
Bismarck	1,674	8	57	28.14	29.90	−.02	57.6	+3.1	83	21	68	36	19	48	35	51	45	67	2.65	+0.2	19	8,131	nw.	42	nw.	17	8	10	13	5.6	0.0	0.0
Devils Lake	1,482	11	44	28.31	29.87	−.07	56.8	+4.1	82	21	67	35	19	47	31	51	46	71	2.71	+0.5	17	7,233	se.	36	ne.	10	8	7	16	6.2	0.0	0.0
Ellendale	1,457	10	56	28.33	29.89	.....	57.3	.....	80	21	68	36	4	47	35	.....	.....	.....	3.69	.....	14	10,613	nw.	59	se.	11	2	13	16	7.1	0.0	0.0
Grand Forks	835	12	89	.....	.....	.....	58.1	.....	83	27	68	40	5	48	30	.....	.....	.....	4.18	.....	16	.....	se.	38	se.	11	15	9	7	.....	0.0	0.0
Williston	1,878	41	48	27.90	29.86	−.07	55.4	+1.1	82	25	65	33	12	45	34	48	42	66	2.64	+0.4	15	9,140	se.	45	ne.	11	7	8	16	6.7	1.5	0.0
Upper Mississippi Valley.																																
							63.7	+3.7												70	3.71	−0.5									5.8		
Minneapolis	918	102	208	28.91	29.88	.....	63.2	.....	86	10	72	41	31	54	27	.....	.....	.....	2.94	−1.0	13	7,49	s.	34	se.	8	3	14	14	6.8	0.0	0.0
St. Paul	837	236	261	29.02	29.91	−.03	62.5	+4.6	85	10	72	42	31	54	28	.....	.....	.....	2.48	−1.1	14	8,874	se.	46	se.	11	5	18	8	6.1	0.0	0.0
La Crosse	714	11	48	29.15	29.91	−.03	64.2	+4.1	89	11	74	47	13	54	31	.....	.....	.....	4.86	+1.1	15	3,294	se.	38	sw.	11	6	12	13	6.2	0.0	0.0
Madison	974	70	78	28.91	29.94	−.02	63.6	+6.0	86	10	72	47	1	55	24	56	52	72	4.16	+0.5	15	5,796	s.	31	s.	6	6	11	14	6.4	0.0	0.0
Wausau	1,247	4	....	28.64	29.97	.....	60.5	.....	85	11	71	41	28	50	37	.....	.....	.....	2.61	.....	13	.....	e.	.....	.....	.....	15	3	13	5.1	0.0	0.0
Charles City	1,015	10	49	28.85	29.92	−.02	62.3	+2.8	87	10	72	44	7	52	33	56	52	73	3.93	−1.0	15	4,803	nw.	28	sw.	11	6	13	12	6.1	0.0	0.0
Davenport	606	71	79	29.27	29.93	−.02	66.0	+4.5	87	11	76	49	19	57	27	58	54	69	3.87	−0.3	16	5,552	e.	31	sw.	5	8	10	13	5.8	0.0	0.0
Des Moines	861	84	97	29.00	29.90	−.03	64.3	+2.7	86	10	74	44	13	55	31	57	51	66	6.87	+2.3	14	5,883	sw.	33	sw.	11	8	12	11	5.7	0.0	0.0
Dubuque	698	81	96	29.20	29.95	.00	64.8	+4.0	87	10	74	48	1	56	26	57	53	71	4.79	+0.5	15	4,410	s.	20	se.	24	7	13	11	6.1	0.0	0.0
Keokuk	614	64	78	29.26	29.93	−.01	66.4	+3.2	87	10	76	49	19	57	26	59	54	66	2.44	−1.8	15	5,049	e.	37	sw.	5	8	13	10	5.5	0.0	0.0
Cairo	356	87	93	29.55	29.92	−.04	70.4	+2.9	87	10	78	54	19	63	22	63	58	70	2.65	−1.2	12	5,260	se.	25	nw.	18	6	10	15	6.7	0.0	0.0
Peoria	609	11	45	29.28	29.94	−.02	65.6	+3.9	87	11	76	45	17	56	29	60	56	74	4.60	+0.3	15	4,134	s.	26	w.	6	14	10	7	4.5	0.0	0.0
Springfield, Ill	644	16	91	29.25	29.92	−.03	67.0	+3.5	86	11	77	49	17	58	27	60	55	71	4.64	+0.2	13	5,758	se.	29	w.	18	11	11	9	5.2	0.0	0.0
Hannibal	534	74	109	29.36	29.92	−.02	67.4	+3.0	87	11	76	48	20	58	28	.....	.....	.....	2.44	−2.6	17	5,966	sw.	27	sw.	24	10	14	7	5.0	0.0	0.0
St. Louis	567	265	303	29.32	29.92	−.03	69.4	+2.5	88	11	78	54	19	61	22	61	57	69	1.26	−3.0	6	8,547	s.	37	sw.	6	7	18	6	5.3	0.0	0.0
Missouri Valley.																																
							63.7	+2.0												67	3.09	−1.2									5.4		
Columbia, Mo	781	11	84	29.09	29.91	−.03	66.2	+1.7	87	11	76	47	15	56	32	.....	.....	.....	4.34	−0.5	15	5,044	se.	31	nw.	18	10	9	12	5.3	0.0	0.0
Kansas City	963	161	181	28.88	29.90	−.02	66.8	+2.3	83	5	75	49	19	59	25	59	54	67	2.83	−2.3	13	7,496	s.	38	nw.	18	9	14	8	5.0	0.0	0.0
St. Joseph	967	11	49	28.86	29.89	.....	66.0	.....	85	5	75	47	19	57	30	58	53	68	6.56	.....	12	6,053	nw.	31	nw.	18	9	15	7	5.0	0.0	0.0
Springfield, Mo	1,324	98	104	28.53	29.92	−.01	66.4	+1.8	83	10	74	50	17	58	25	59	55	72	3.94	−1.6	12	6,859	se.	36	w.	3	15	11	5	4.0	0.0	0.0
Iola	984	11	50	28.86	29.88	−.04	67.6	+3.1	87	21	78	47	14	57	32	.....	.....	.....	3.70	−1.4	13	4,755	s.	31	w.	3	8	13	10	5.5	0.0	0.0
Topeka	987	92	107	.....	.....	.....	66.0	+1.0	87	5	76	47	19	56	33	.....	.....	.....	3.93	−1.0	13	7,265	n.	40	sw.	9	7	14	10	5.9	0.0	0.0
Drexel	1,299	10	54	28.52	29.90	.....	62.0	.....	86	5	73	40	4	51	38	.....	.....	.....	2.43	.....	12	8,488	nw.	39	sw.	11	8	13	10	5.8	0.0	0.0
Lincoln	1,189	11	84	28.64	29.88	−.03	63.8	+0.9	89	5	75	40	19	53	38	56	49	66	3.22	−1.0	14	7,853	n.	39	sw.	11	6	14	9	5.4	0.0	0.0
Omaha	1,105	115	122	28.74	29.90	−.02	64.6	+2.1	88	5	74	46	4	55	34	56	50	65	2.37	−2.1	10	6,345	nw.	33	nw.	3	12	9	10	5.0	0.0	0.0
Valentine	2,598	47	54	27.21	29.90	.00	58.0	+0.1	84	10	70	35	4	46	36	50	44	65	2.67	−0.7	13	8,285	nw.	51	s.	11	7	16	8	5.2	0.0	0.0
Sioux City	1,135	94	164	28.71	29.91	−.01	62.8	+2.0	83	5	72	44	31	54	32	54	47	62	2.23	−2.1	11	9,385	s.	48	sw.	11	8	10	13	6.1	0.0	0.0
Huron	1,306	59	74	28.53	29.92	.00	59.7	+3.3	81	21	70	39	7	49	32	54	48	68	2.47	−0.4	11	7,969	se.	52	s.	11	13	11	7	4.4	0.0	0.0
Pierre	1,572	70	75	28.33	29.88	−.03	60.3	+2.3	82	28	70	39	19	50	33	54	48	69	3.58	+1.4	12	8,332	nw.	46	w.	12	6	12	13	6.2	0.0	0.0
Yankton	1,233	49	57	28.59	29.89	−.03	62.2	+2.8	87	9	72	42	31	52	35	.....	.....	.....	1.77	−2.1	12	6,919	nw.	40	sw.	11	5	13	13	6.5	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, May, 1922*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F*	° *F.*		° *F*	° *F.*	° *F.*	° *F.*	*N*	*In.*	*In.*		*Miles.*									*0–10*	*In.*	*In.*
Northern Slope.							**52.7**	**−0.2**										**60**	**2.29**	**−0.1**										**5.6**		
Billings	3,140	5	....				55.2	.....	96	25	70	32	9	41	51	.....	.....	.....	2.05	.....	15	.....	nw.	.....	.....	.....	6	12	13	.....	0.0	0.0
Havre	2,505	11	44	27.32	29.94	+.04	53.8	+0.4	93	25	65	32	15	42	42	46	39	64	2.47	+0.4	14	7,069	sw.	42	nw.	12	7	14	10	5.9	0.0	0.0
Helena	4,110	87	112	25.79	29.97	+.04	50.8	−0.8	86	24	61	33	8	40	39	41	31	51	1.63	−0.3	12	7,366	sw.	40	sw.	25	2	14	15	6.9	3.5	0.0
Kalispell	2,973	48	56	26.93	29.98	+.10	50.4	−0.6	80	24	62	29	9	39	38	41	32	55	0.76	−1.3	8	4,375	se.	30	sw.	2	13	12	6	4.7	0.0	0.0
Miles City	2,371	26	48	27.42	29.96	+.05	57.6	+0.9	88	25	69	34	11	46	34	49	44	71	4.75	+2.8	18	6,837	nw.	38	nw.	11	7	17	7	5.9	10.0	0.0
Rapid City	3,259	50	58	26.55	29.94	+.04	56.0	+1.8	80	26	66	37	11	46	32	47	39	60	3.73	+0.8	14	7,765	n.	46	n.	11	7	14	10	5.7	0.0	0.0
Cheyenne	6,088	84	101	23.98	29.90	+.05	49.8	−1.2	76	25	62	28	16	38	38	41	33	57	2.00	−0.4	10	10,921	w.	68	w.	11	8	13	10	5.4	2.3	0.5
Lander	5,372	60	68	24.62	29.94	+.06	51.8	−0.2	82	25	64	29	1	40	39	42	34	58	1.70	−1.2	6	4,923	w.	42	sw.	20	13	12	6	4.8	1.0	0.0
Sheridan	3,790	10	47	26.08	29.96	.....	52.4	.....	88	25	64	33	1	41	39	44	37	63	3.04	.....	15	6,356	nw.	45	nw.	11	4	16	11	5.8	T.	0.0
Yellowstone Park	6,200	11	48	23.87	29.97	+.06	44.6	−2.8	75	25	56	25	9	34	38	37	29	59	1.08	−0.8	15	6,933	s.	43	S.	18	5	15	11	6.1	2.0	0.0
North Platte	2,821	11	51	27.04	29.94	+.06	59.5	+0.8	86	9	72	35	4	47	43	51	45	66	2.53	−0.5	9	6,146	n.	40	w.	11	12	8	11	4.9	0.0	0.0
Middle Slope.							**63.3**	**+0.5**										**65**	**3.59**	**−0.2**										**5.4**		
Denver	5,292	106	113	24.69	29.89	+.05	57.7	+1.5	83	26	69	36	15	46	35	45	33	47	1.14	−1.4	8	6,421	s.	36	w.	10	11	10	10	5.3	T.	0.0
Pueblo	4,685	80	86	25.23	29.89	+.06	59.4	−0.1	87	5	73	36	14	46	39	47	36	52	1.67	0.0	10	5,710	e.	40	w.	10	10	17	4	5.1	0.0	0.0
Concordia	1,392	50	58	28.45	29.91	.00	64.2	+0.5	85	17	74	46	14	54	32	57	52	70	3.54	−1.2	14	6,299	s.	34	sw.	3	4	18	9	6.4	0.0	0.0
Dodge City	2,509	11	51	27.36	29.93	+.06	63.6	+0.1	86	17	75	44	16	52	36	56	51	71	2.77	−0.6	13	7,679	ne.	47	se.	10	17	7	7	3.8	0.0	0.0
Wichita	1,358	139	158	28.46	29.87	−.03	66.2	+0.3	83	20	75	48	16	58	30	60	56	73	5.60	+0.6	14	8,470	s.	46	sw.	9	13	10	8	5.0	0.0	0.0
Altus	1,410	5	....	....	....	.....	70.2	.....	98	26	82	50	17	59	37	.....	.....	.....	4.54	.....	11	.....	.....	.....	.....	.....	.....	14	2	15	.....	0.0	0.0
Broken Arrow	765	11	52	29.09	29.90	.....	68.4	.....	86	26	77	51	14	60	28	.....	.....	.....	6.37	.....	18	7,751	se.	56	nw.	20	5	14	12	6.1	0.0	0.0
Muskogee	652	4	....	....	....	.....	71.0	.....	90	27	81	51	14	61	33	.....	.....	.....	7.24	.....	18	.....	w.	.....	.....	.....	6	14	11	.....	0.0	0.0
Oklahoma City	1,214	10	47	28.63	29.89	.00	68.8	+0.7	90	21	78	53	17	60	30	63	60	78	6.83	+1.1	13	7,380	s.	40	nw.	21	10	11	10	5.7	0.0	0.0
Southern Slope.							**71.2**	**+0.6**										**55**	**2.42**	**−0.4**										**4.0**		
Abilene	1,738	10	52	28.09	29.86	−.01	72.6	+0.7	96	20	84	48	17	61	35	62	57	66	5.34	+1.6	10	6,746	s.	35	s.	3	12	12	7	4.4	0.0	0.0
Amarillo	3,676	10	49	26.22	29.88	+.04	65.0	+0.7	91	26	77	44	11	53	33	55	48	61	1.60	−2.1	10	7,644	se.	46	s.	10	18	11	2	3.3	0.0	0.0
Del Rio	944	64	71	28.88	29.85	.00	79.0	+2.1	98	5	89	60	17	69	27	.....	.....	.....	1.23	−1.2	7	6,700	se.	42	e.	14	10	13	8	4.8	0.0	0.0
Roswell	3,566	75	85	26.29	29.83	+.01	68.3	−1.1	95	27	82	45	3	54	38	51	34	39	1.50	+0.3	7	6,695	e.	41	sw.	10	16	9	6	3.6	0.0	0.0
Southern Plateau.							**69.5**	**+0.5**										**31**	**0.19**	**−0.2**										**1.9**		
El Paso	3,762	110	133	26.11	29.79	+.01	73.0	+0.9	93	27	86	43	11	60	34	51	29	25	0.36	0.0	4	9,616	w.	42	w.	10	23	8	0	1.8	0.0	0.0
Santa Fe	7,013	38	53	23.23	29.81	−.03	55.9	−0.8	80	27	69	28	11	43	36	42	26	38	0.29	−0.8	4	5,749	sw.	35	sw.	10	18	11	2	3.3	T.	0.0
Flagstaff	6,908	10	59	....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phoenix	1,108	76	81	28.66	29.79	+.01	76.4	+1.6	105	29	93	44	11	59	45	55	36	30	0.26	+0.2	1	4,143	w.	29	w.	9	25	5	1	1.5	0.0	0.0
Yuma	141	9	54	29.66	29.80	+.01	77.6	+0.8	108	29	95	45	10	60	45	57	40	34	0.05	0.0	1	4,186	w.	41	w.	9	25	5	1	1.2	0.0	0.0
Independence	3,957	9	41	25.92	29.91	+.07	64.6	+0.1	89	30	80	36	11	50	38	47	29	30	T.	−0.2	0	5,354	nw.	33	nw.	25	24	7	0	1.8	T.	0.0
Middle Plateau.							**56.3**	**0.0**										**41**	**0.85**	**−0.3**										**3.3**		
Reno	4,532	74	81	25.48	29.96	+.05	55.0	+1.4	84	30	70	27	11	40	42	41	28	43	0.10	−0.7	2	6,003	w.	37	w.	25	19	10	2	2.8	T.	0.0
Tonopah	6,090	12	20	24.05	29.90	.....	56.4	.....	80	29	68	21	9	44	35	42	26	36	0.38	−1.0	2	6,405	w.	51	w.	25	13	16	2	3.5	2.5	0.0
Winnemucca	4,344	18	56	25.62	30.00	+.09	54.4	0.0	84	17	70	22	11	38	42	41	28	45	0.47	−0.6	6	5,763	sw.	34	w.	25	18	7	6	3.5	T.	0.0
Modena	5,479	10	43	24.58	29.89	+.07	53.2	−1.3	82	24	70	20	11	37	43	39	24	40	1.61	+0.7	5	8,593	w.	56	s.	25	22	7	2	2.5	8.8	0.0
Salt Lake City	4,360	163	203	25.60	29.93	+.07	57.6	+0.2	87	24	67	34	9	48	31	45	33	43	2.16	+0.2	7	6,312	nw.	47	sw.	25	19	8	4	3.2	T.	0.0
Grand Junction	4,602	60	68	25.32	29.86	+.03	61.1	−0.5	86	29	75	34	11	48	36	46	32	39	0.40	−0.5	2	4,949	se.	42	s.	8	16	8	7	4.2	T.	0.0
Northern Plateau.							**55.5**	**−1.4**										**52**	**0.84**	**−0.9**										**4.6**		
Baker	3,471	48	53	26.47	30.06	+.10	50.2	−0.5	82	16	63	21	9	37	40	42	33	57	0.41	−1.3	6	4,971	nw.	27	nw.	25	16	4	11	4.4	T.	0.0
Boise	2,739	78	86	27.17	30.02	+.08	56.4	−1.2	88	24	69	28	9	43	38	46	36	53	1.56	+0.3	8	4,199	nw.	28	nw.	10	19	6	6	3.6	0.1	0.0
Lewiston	757	40	48	29.25	30.06	+.10	58.8	−2.0	90	31	72	31	9	46	43	.....	.....	.....	0.60	−1.0	8	3,110	e.	24	nw.	1	10	6	15	5.6	0.0	0.0
Pocatello	4,477	60	68	25.45	29.95	+.06	53.9	−1.6	83	25	66	31	27	42	46	42	31	48	1.84	−0.4	7	6,542	sw.	55	sw.	25	13	11	7	4.5	0.3	0.0
Spokane	1,929	101	110	27.98	30.03	+.07	54.6	−1.5	85	31	66	29	9	43	38	44	34	50	0.16	−1.5	3	4,616	sw.	31	sw.	4	10	10	11	5.3	T.	0.0
Walla Walla	991	57	65	28.97	30.04	+.08	59.0	−1.7	91	31	70	32	9	48	38	49	39	51	0.46	−1.4	5	4,286	sw.	20	w.	4	16	9	6	4.2	0.0	0.0
North Pacific Coast Region.							**54.1**	**+0.2**										**72**	**1.89**	**−0.5**										**5.8**		
North Head	211	11	56	29.88	30.11	+.08	50.7	−0.5	85	30	56	35	8	46	30	47	44	82	2.54	+0.2	16	11,556	n.	70	s.	20	6	18	7	5.5	T.	0.0
Port Angeles	29	8	53	30.08	30.10	.....	48.8	.....	74	31	57	32	9	40	27	.....	.....	.....	0.34	−1.0	8	4,892	s.	34	w.	18	12	8	11	5.1	0.0	0.0
Seattle	125	215	250	29.98	30.11	+.10	54.5	−0.5	89	31	63	36	7	46	30	47	41	66	1.08	−0.9	13	7,489	s.	37	sw.	1	9	11	11	5.4	0.0	0.0
Tacoma	213	113	120	29.89	30.11	+.09	54.6	+0.1	86	31	64	34	9	45	38	.....	.....	.....	1.48	−1.1	13	5,328	sw.	37	ne.	28	3	16	12	6.5	T.	0.0
Tatoosh Island	86	7	57	29.99	30.09	+.08	49.2	−0.4	79	31	54	36	8	44	27	46	44	84	5.19	+1.1	18	10,134	s.	58	s.	3	3	6	22	7.6	T.	0.0
Yakima	1,071	4	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Medford	1,425	4	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portland, Oreg.	153	68	106	29.93	30.09	+.03	58.0	+1.1	94	31	68	37	8	48	34	50	42	62	1.60	−0.8	13	5,222	nw.	26	e.	28	8	8	15	6.1	T.	0.0
Roseburg	510	9	57	29.55	30.10	+.07	57.7	+1.7	95	30	71	33	8	45	49	49	42	65	1.03	−1.0	12	2,516	n.	18	n.	14	15	11	5	3.8	1.5	0.0
Middle Pacific Coast Region.							**59.0**	**+0.8**										**63**	**0.60**	**−0.7**										**3.6**		
Eureka	62	73	89	30.06	30.14	+.09	51.0	−1.1	73	15	56	37	9	46	27	47	45	83	0.95	−1.6	7	5,102	n.	36	n.	15	9	8	14	6.3	0.0	0.0
Point Reyes	490	7	18	29.46	29.98	.....	50.4	−1.2	79	15	55	41	9	46	29	.....	.....	.....	0.39	.....	3	20,349	nw.	73	nw.	9	14	7	10	4.6	0.0	0.0
Red Bluff	332	50	56	29.60	29.95	.00	68.6	+2.3	100	30	82	34	9	55	38	54	42	45	0.56	−0.8	5	5,033	nw.	28	nw.	7	25	3	3	2.3	0.0	0.0
Sacramento	69	106	117	29.88	29.95	+.01	65.9	+2.6	93	29	79	42	9	53	41	54	43	59	0.43	−0.6	5	6,318	s.	28	nw.	26	25	3	3	1.8	0.0	0.0
San Francisco	155	208	243	29.84	30.01	+.02	58.0	+2.5	87	14	66	44	9	50	30	51	46	73	0.55	−0.3	2	7,722	w.	40	w.	6	21	2	8	3.6	0.0	0.0
San Jose	141	12	110	29.86	30.00	.....	60.2	−0.5	92	14	74	38	11	46	41	.....	.....	.....	0.50	−0.2	4	4,549	nw.	28	nw.	9	19	7	5	3.2	0.0	0.0
South Pacific Coast Region.							**62.9**	**+0.8**										**66**	**0.56**	**0.0**										**3.2**		
Fresno	327	89	98	29.59	29.94	+.02	68.6	+0.2	95	30	83	39	9	54	38	54	40	45	0.49	−0.1	4	6,254	nw.	34	nw.	7	24	5	2	1.8	0.0	0.0
Los Angeles	338	159	191	29.59	29.96	+.01	62.6	+0.1	92	13	72	43	10	53	28	55	50	74	0.65	+0.2	2	4,093	sw.	28	sw.	9	17	9	5	3.4	0.0	0.0
San Diego	87	62	70	29.86	29.96	+.01	60.3	−0.5	81	13	66	48	11	55	25	55	52	78	0.36	0.0	2	4,973	nw.	41	s.	9	11	11	9	5.0	0.0	0.0
San Luis Obispo	201	32	40	29.79	30.01	+.01	60.2	+3.5	95	13	72	38	10	48	40	51	45	68	0.72	−0.2	5	3,682	nw.	25	nw.	9	21	6	4	2.7	0.0	0.0
West Indies.																																
San Juan, P. R	82	8	54	29.93	30.02	.....	77.5	.....	90	29	83	70	9	72	17	.....	.....	.....	3.84	−0.9	13	9,569	e.	34	e.	31	6	15	10	6.1	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97	29.71	29.83	−.01	80.6	0.0	94	2	86	71	22	75	18	75	74	83	9.88	+1.6	18	4,841	nw.	25	s.	11	0	10	21	7.7	0.0	0.0
Colon	36	7	97	29.80	29.83	−.01	81.9	+1.6	91	12	87	72	23	76	17	76	75	83	8.88	−3.5	22	5,979	n.	23	ne.	22	0	13	18	7.7	0.0	0.0
Alaska.																																
Juneau	80	11	49	29.83	29.91	.....	46.4	.....	79	29	55	32	7	38	34	42	37	72	5.12	.....	19	5,361	se.	35	se.	21	7	6	18	6.8	T.	0.0

TABLE 2.—*Data furnished by the Canadian Meteorological Service, May, 1922.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	*°F*	*°F*	*°F*	*°F*	*°F*	*°F*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20	29.97	29.99	+0.06	45.3	+1.3	53.7	36.9	68	28	2.16	−0.42	
Quebec, Que.	296	29.68	30.00	+.06	55.0	+5.1	65.4	44.7	80	30	2.79	−0.29	
Montreal, Que.	187	29.76	29.96	+.02	59.0	+4.3	68.9	49.1	83	40	1.77	−1.18	
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.72	29.98	+.04	60.0	+10.1	71.9	48.0	86	31	1.92	−0.67	
Kingston, Ont.	285	29.68	29.99	+.03	57.9	+5.0	66.6	49.3	77	40	1.99	−0.69	
Toronto, Ont.	379	29.57	29.97	−.01	59.7	+6.5	70.5	48.8	80	35	1.46	−1.58	
Cochrane, Ont.	930												
White River, Ont.	1,244	28.66	29.96	+.01	54.3	+8.6	69.9	38.7	82	27	1.18	−0.77	
Port Stanley, Ont.	592	29.36	30.00	+.03	56.5	+3.4	66.6	46.5	80	29	1.84	−1.31	
Southampton, Ont.	656	29.27			56.1	+5.4	66.0	46.2	80	33	1.54	−0.90	
Parry Sound, Ont.	688	29.28	29.96	+.01	57.7	+6.6	69.3	46.1	85	29	2.09	−0.84	
Port Arthur, Ont.	644	29.27	29.98	+.02	53.0	+7.1	62.4	44.8	85	35	1.35	−0.80	
Winnipeg, Man.	760	29.06	29.88	−.08	60.1	+8.5	71.7	48.4	83	33	2.65	+0.37	
Minnedosa, Man.	1,690	28.08	29.88	−.08	55.1	+6.7	66.5	43.8	82	32	2.10	+0.65	
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.61	29.83	−.11	54.0	+4.2	64.1	43.9	82	37	3.47	+1.82	
Medicine Hat, Alb.	2,144												
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.38	29.99	+.07	52.6	+1.9	63.9	41.4	88	31	3.27	+1.51	
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Edmonton, Alb.	2,150	27.59	29.86	−.12	51.8	+1.0	66.0	37.6	82	29	1.28	−0.27	0.5
Prince Albert, Sask.	1,450	28.32	29.87	−.06	54.6	+7.0	66.1	43.2	86	33	3.09	+1.83	0.7
Battleford, Sask.	1,592	28.12	29.84	−.08	56.6	+5.6	70.0	43.3	90	35	2.93	+1.31	
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.84	30.10	+.10	53.1	+0.6	60.8	45.4	84	35	0.49	−0.99	
Barkerville, B. C.	4,180												
LATE REPORTS FOR APRIL, 1922.													
Barkerville	4,180	25.63	29.99	+.13	32.3	−0.8	42.1	22.6	58	6	3.55	+1.73	33.6
Chatham	28	29.91	29.98	+.08	39.9	+4.4	48.3	31.5	64	22	1.97	−0.66	8.3
Halifax	88	29.79	29.90	−.06	40.1	+2.3	47.3	32.9	62	24	3.43	−0.75	T.
Sydney	48	29.84	29.89	.00	36.5	+1.5	42.4	30.7	58	22	2.37	−1.48	1.5
Charlottetown	38	29.85	29.89	−.01	37.2	+2.0	43.0	31.5	57	23	2.22	−0.43	0.7
Hamilton, Bermuda	151	29.98	30.15	+.10	64.8	+0.9	70.3	59.4	76	48	2.92	−1.26	
St. Johns	125	29.56	29.70	−.19	35.1	+0.6	40.0	30.2	50	20	4.96	+0.80	1.0
Yarmouth	65	29.85	29.92	−.04	40.0	+1.2	46.2	34.0	56	24	1.97	−1.42	4.8

SEISMOLOGICAL REPORTS FOR MAY, 1922.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, June 30, 1922.]

TABLE 1.—*Noninstrumental earthquake reports, May, 1922.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1922.	*H. m.*		° ′	° ′			*Sec.*			
14	10 12	Oakland	37 38	122 15	2-3?	2?	?,2	None	Awakened by first shock	Mrs. R. N. Allen.
15	20 30	Quincy	40 00	121 00	4	1	Several.	do	Felt by many	Associated Press.
30	22 25	Paso Robles	35 40	120 15	?	2	5	do	Felt by several	Mrs. A. Z. Campbell.
		NEW HAMPSHIRE.								
7	22 40	Pittsfield	43 20	71 20	4?		Few.			Press report.

TABLE 2.—*Instrumental seismological reports, May, 1922.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols and description of stations, see REVIEW for January, 1922.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
CALIFORNIA. *Theosophical University, Point Loma.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 13	.....	.....	.....	.....	200	200	.....	Tremors in preceding 24 hours.
14	.....	.....	.....	.....	100	100	.....	
23	.....	.....	.....	.....	50	50	.....	
DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1	.....	e.....	12 44 ..	.....	.....	.....	.....	Minute and irregular.
		F.....	13	.....	.....	.....	.....	
4	.....	P.....	9 26 ..	.....	.....	.....	8,800	
		S.....	9 36 ..	.....	.....	.....	.....	
		eL.....	9 56 ..	16	.....	.....	.....	
		F.....	10 45 *ca*	.....	.....	.....	.....	
11	.....	P.....	6 52 40	.....	.....	.....	3,400	
		S.....	6 57 51	.....	.....	.....	.....	
		L?.....	7 01 00	.....	.....	.....	.....	
		F.....	7 25 *ca*	.....	.....	.....	.....	
12	.....	e.....	19 17 ..	.....	.....	.....	.....	
		eL.....	19 41 ..	16	.....	.....	.....	
		F.....	20 15 ..	.....	.....	.....	.....	
ILLINOIS. *U. S. Weather Bureau, Chicago.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1	.....	eL.....	12 47 10	18	.....	.....	.....	
		L.....	13 01 ..	16	.....	.....	.....	
		F.....	13 20 *ca*	.....	.....	.....	.....	
2	.....	e.....	11 50 30	.....	.....	.....	.....	
		L.....	12 15 ..	18	.....	.....	.....	
		L.....	12 20 ..	16	.....	.....	.....	
		F.....	13 10 *ca*	.....	.....	.....	.....	
3	.....	P?.....	4 17 40	.....	.....	.....	.....	Small amplitudes.
		L?.....	4 32 ..	.....	.....	.....	.....	
		L.....	4 34 ..	16	.....	.....	.....	
		F.....	5 50 *ca*	.....	.....	.....	.....	
4	.....	P.....	9 24 41	.....	.....	.....	8,100	
		iS.....	9 34 27	.....	.....	.....	.....	
		eL.....	9 48 55	.....	.....	.....	.....	
		L.....	9 58 ..	20	.....	.....	.....	
		L.....	10 02 ..	16	.....	.....	.....	
		F.....	12 40 *ca*	.....	.....	.....	.....	
5	.....	e.....	0 53 15	.....	.....	.....	.....	
		eL.....	1 01 20	16	.....	.....	.....	
		F.....	1 30 *ca.*	.....	.....	.....	.....	
11	.....	P?.....	1 00 35	.....	.....	.....	5,800	
		S.....	1 08 00	.....	.....	.....	.....	
		L.....	1 28 ..	.....	.....	.....	.....	
		F.....	2 *ca.*	.....	.....	.....	.....	
11	.....	P.....	6 52 55	.....	.....	.....	4,400	
		S.....	6 59 05	.....	.....	.....	.....	
		L.....	7 04 10	20	.....	.....	.....	
		F.....	8 *ca.*	.....	.....	.....	.....	
11	.....	e.....	9 41 ..	.....	.....	.....	.....	
		L.....	10 05 ..	20	.....	.....	.....	
		F.....	12 *ca.*	.....	.....	.....	.....	
12	.....	e.....	18 59 00	.....	.....	.....	.....	
		S?.....	19 09 30	.....	.....	.....	.....	
		L.....	19 34 ..	22	.....	.....	.....	
		L.....	19 39 ..	18	.....	.....	.....	
		L.....	19 46 ..	16	.....	.....	.....	
		F.....	22 *ca.*	.....	.....	.....	.....	
14	.....	e.....	23 27 30	.....	.....	.....	.....	
		F.....	23 50 ..	.....	.....	.....	.....	
21	.....	e?.....	1 12 10	.....	.....	.....	.....	
		L.....	1 24 ..	16	.....	.....	.....	
		F.....	1 50 *ca.*	.....	.....	.....	.....	
22	.....	e.....	18 50 ..	.....	.....	.....	.....	Slight.
		F.....	20	.....	.....	.....	.....	
28	.....	P?.....	0 41 30	.....	.....	.....	.....	
		eL?...	1 00 00	16	.....	.....	.....	
		F.....	1 30 *ca.*	.....	.....	.....	.....	
28	.....	e?.....	4 45 ..	.....	.....	.....	.....	
		eL.....	5 05 ..	18	.....	.....	.....	
		L.....	5 20 ..	16	.....	.....	.....	
		F.....	6 *ca.*	.....	.....	.....	.....	
NEW YORK, *Fordham University, New York.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 12	.....	P_E.....	19 25 11	.....	.....	.....	.....	Clock correction uncertain; preliminaries obscured by heavy locals.
		S_E.....	19 30 35	.....	.....	.....	.....	
		L_E.....	19 41 *ca*	.....	.....	.....	.....	
CANAL ZONE, *Panama Canal, Balboa Heights.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 22	.....	P_E.....	17 33 40	.....	.....	.....	160 *ca.*	Direction unknown.
		P_N.....	17 33 44	.....	.....	.....	.....	
		S_E.....	17 33 59	.....	.....	.....	.....	
		S_N.....	17 34 02	.....	.....	.....	.....	
		L_E.....	17 34 01	.....	.....	.....	.....	
		M_E.....	17 34 05	.....	*1,300	.....	.....	M_R, *500.
		F_E.....	17 36 42	.....	.....	.....	.....	
		F_N.....	17 36 42	.....	.....	.....	.....	
23	.....	P_E.....	21 14 47	.....	.....	.....	220 *ca*	Direction unknown.
		P_N.....	21 14 45	.....	.....	.....	.....	
		L_E.....	21 15 11	.....	.....	.....	.....	
		L_N.....	21 15 10	.....	.....	.....	.....	
		M_E.....	21 15 14	.....	*7,500	.....	.....	
		M_N.....	21 15 15	.....	.....	*2,900	.....	
		F_E.....	21 21 31	.....	.....	.....	.....	
		F_N.....	21 21 53	.....	.....	.....	.....	
23	.....	P_E.....	21 24 43	.....	.....	.....	.....	
		P_N.....	21 24 46	.....	.....	.....	.....	
		L_E.....	21 25 03	.....	.....	.....	.....	
		L_N.....	21 25 08	.....	.....	.....	.....	
		M_E.....	21 25 05	.....	*2,100	.....	.....	
		M_N.....	21 25 10	.....	.....	*2,000	.....	
		F_E.....	21 27 35	.....	.....	.....	.....	
		F_N.....	21 27 46	.....	.....	.....	.....	
25	.....	.....	.....	.....	.....	.....	.....	Slight movement at 19:22:24.
28	.....	.....	.....	.....	.....	.....	.....	Slight movement between 6:25 and 6:27.

*Trace amplitude.

VERMONT, *U. S. Weather Bureau, Northfield.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 12	.....	eL.....	19 45 ..	.....	.....	.....	.....	
		L.....	19 50 ..	16	.....	.....	.....	
		F.....	20	.....	.....	.....	.....	
CANADA, *Dominion Observatory, Ottawa.*								
May 1	.....	e_E.....	12 54 24	.....	.....	.....	.....	
		eL.....	13 05 30	.....	.....	.....	.....	
		L.....	13 12 ..	.....	.....	.....	.....	
		F.....	.....	.....	.....	.....	.....	Lost in changing sheets.
3	.....	*O*.....	4 00 23	.....	.....	.....	6,620	
		P_V.....	4 10 30	.....	.....	.....	.....	
		S.....	4 18 39	.....	.....	.....	.....	
		eL_E...	4 29 23	.....	.....	.....	.....	
		L.....	4 32 ..	.....	.....	.....	.....	
		F.....	5 30 *ca*	.....	.....	.....	.....	
4	.....	*O*.....	9 12 59	.....	.....	.....	8,680	
		P.....	9 24 55	.....	.....	.....	.....	
		S.....	9 34 49	.....	.....	.....	.....	
		eL_E...	9 45 ..	.....	.....	.....	.....	Small sinusoidal L waves.
		L.....	9 50 ..	12	.....	.....	.....	
		L.....	9 56 ..	21	.....	.....	.....	
		L.....	10 02 ..	17	.....	.....	.....	
		F.....	12 00 *ca*	.....	.....	.....	.....	
5	.....	$eL?_E$..	0 58 30	.....	.....	.....	.....	
		L.....	1 06 ..	.....	.....	.....	.....	
		F.....	1 25 *ca*	.....	.....	.....	.....	
11	.....	iL_M...	1 08 49	.....	.....	.....	.....	Subscripts M refer to Milne-Shaw, horizontal, N–S comp.
		L_M.....	1 26 ..	23	.....	.....	.....	
		L_M.....	1 49 ..	19	.....	.....	.....	
		F.....	(2 02)	.....	.....	.....	.....	

CANADA, *Dominion Observatory, Ottawa*—Continued.

May 11		*O*.....	6 45 25				4,000	
		P.....	6 52 43					
		PR27..	6 54 04					
		S.....	6 58 30					
		SR27..	7 01 11					
		eL_M...	7 05 ..					
		F.....	8 00 *ca*					
	11	$e?_E$....	9 48 48					
		$e?_M$...	9 51 18					
		eL_M...	10 07 ..					
		L.....	10 15 ..	28				
		L.....	10 30 ..	17				
		L.....	10 53 ..	15				
		L.....	11 28 ..					
		F.....	11 58 ..					
	12	$e?_{EVM}$..	19 00 ..					
		i_M.....	19 03 49					
		e_V.....	19 07 ..					
		e_M.....	19 12 11					Regular sinusoidal L waves; only a slight indication of the other phases.
		eL_M...	19 17 ..					
		L_E....	19 37 30	20				
		L.....	19 40 30	22				
		L.....	19 44 ..	19				
		L.....	19 48 ..	19				
		M_M...	19 50 ..	19				
		L_E....	20 00 ..	15				
		L_{EM}...	20 11 30	15				
		L_{EM}...	20 50 ..	17				
		F.....	21 20 *ca*					
	14	e_M....	23 30 09					Bosch instruments being repaired. Lost in micros.
		eL_M...	23 34 ..					
		F.....						
	22	e_M....	17 52 30					Very slight sinusoidal waves, barely visible on horizontal instruments only.
		eL.....	18 00 ..					
		L.....	19 02 ..	17				
		F.....	19 40 ..					
	28	e_M....	0 44 24					Slight record; the slower speed of the Milne-Shaw recording apparatus alone enabled the waves of small amplitude to show up.
		i_M.....	0 51 20					
		eL.....	0 56 ..					
		L.....	1 04 ..					
		F.....	1 25 ..					
	28	eL_{EM}..	5 05 ..					
		L.....	5 18 ..	17				
		L.....	5 25 ..	17				
		F.....	5 45 ..					

No earthquakes were recorded at the following stations during May, 1922:

COLORADO. *Regis College*, Denver.

Reports for May, 1922, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.

ALASKA. *U. S. C. & G. S. Magnetic Observatory*, Sitka.

ARIZONA. *U. S. C. & G. S. Magnetic Observatory*, Tucson.

DISTRICT OF COLUMBIA. *Georgetown University*, Washington.

HAWAII. *U. S. C. & G. S. Magnetic Observatory*, Honolulu.

MARYLAND. *U. S. C. & G. S. Magnetic Observatory*, Cheltenham.

MASSACHUSETTS. *Harvard University*, Cambridge.

MISSOURI. *St. Louis University, St. Louis.*

NEW YORK. *Cornell University*, Ithaca.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory*, Vieques.

CANADA. *Dominion Meteorological Service*, Toronto *and* Victoria.

Chart I. Tracks of Centers of Anticyclones, May, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.

Chart I. Tracks of Centers of Anticyclones, May, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.

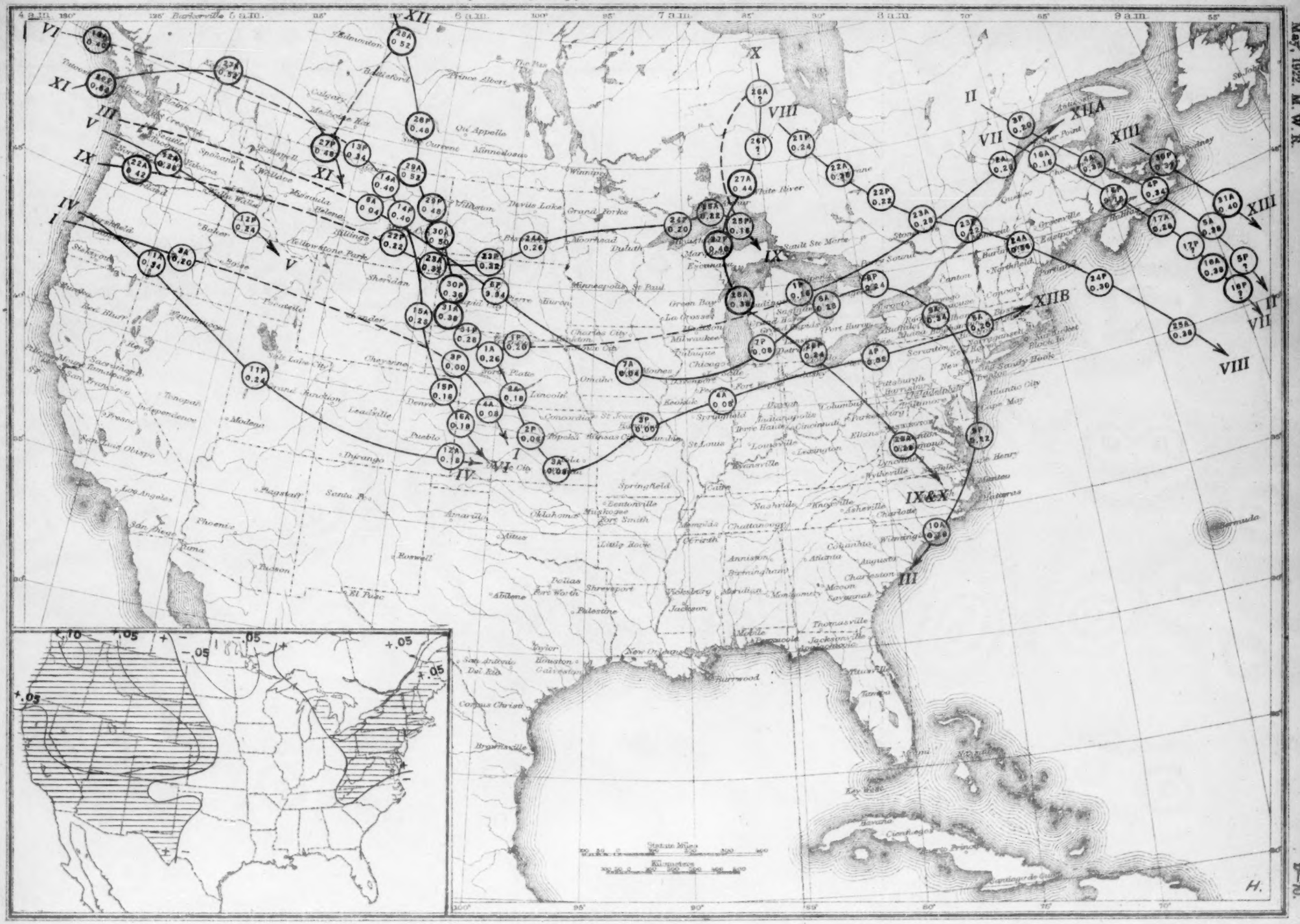


Chart II. Tracks of Centers of Cyclones, May, 1922. (Inset) Change in Mean Pressure from Preceding Month.

(Plotted by Wilfred P. Day.)

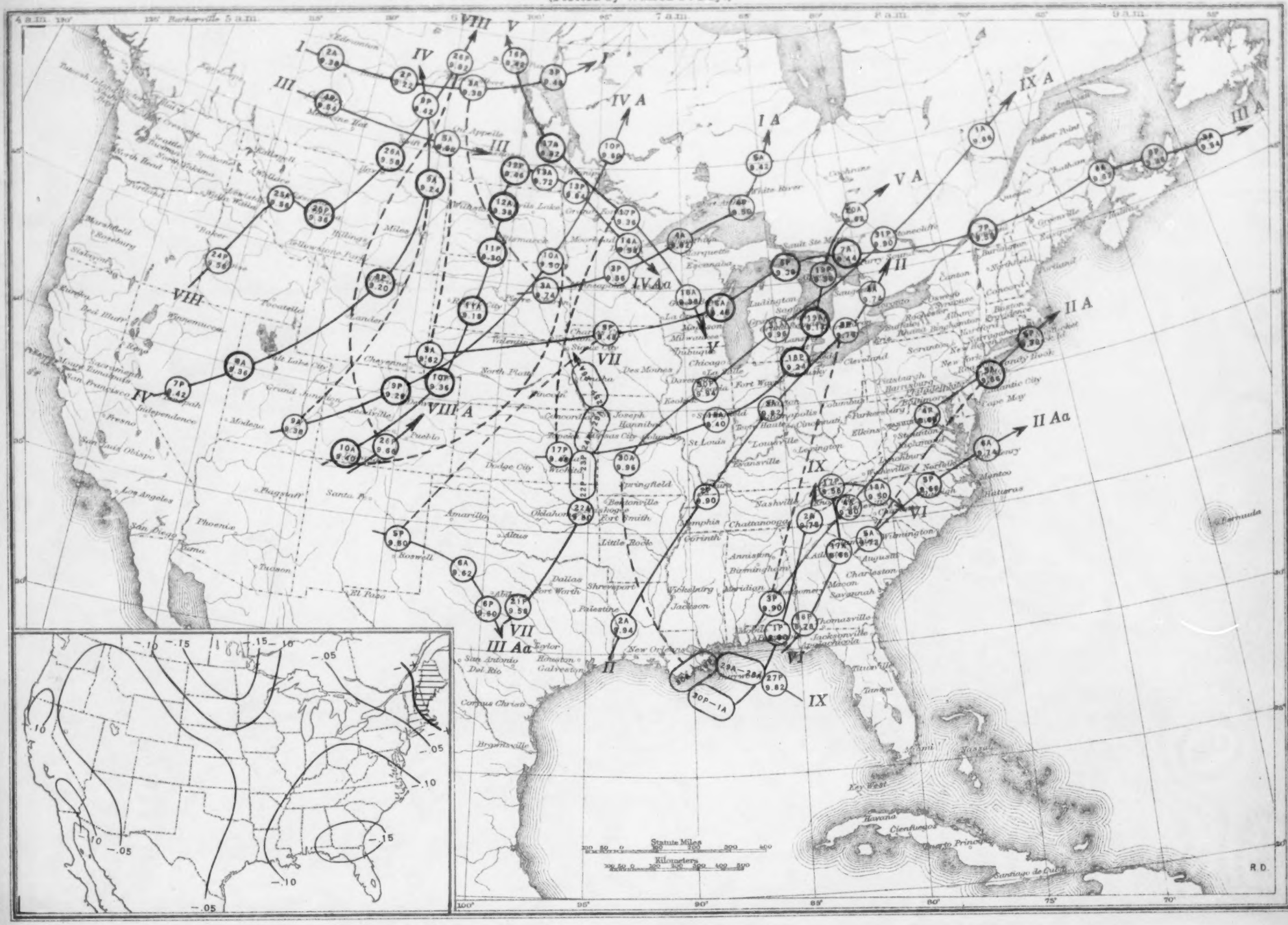


Chart III. Departure (°F.) of the Mean Temperature from the Normal, May, 1922.

Chart III. Departure (°F.) of the Mean Temperature from the Normal, May, 1922.

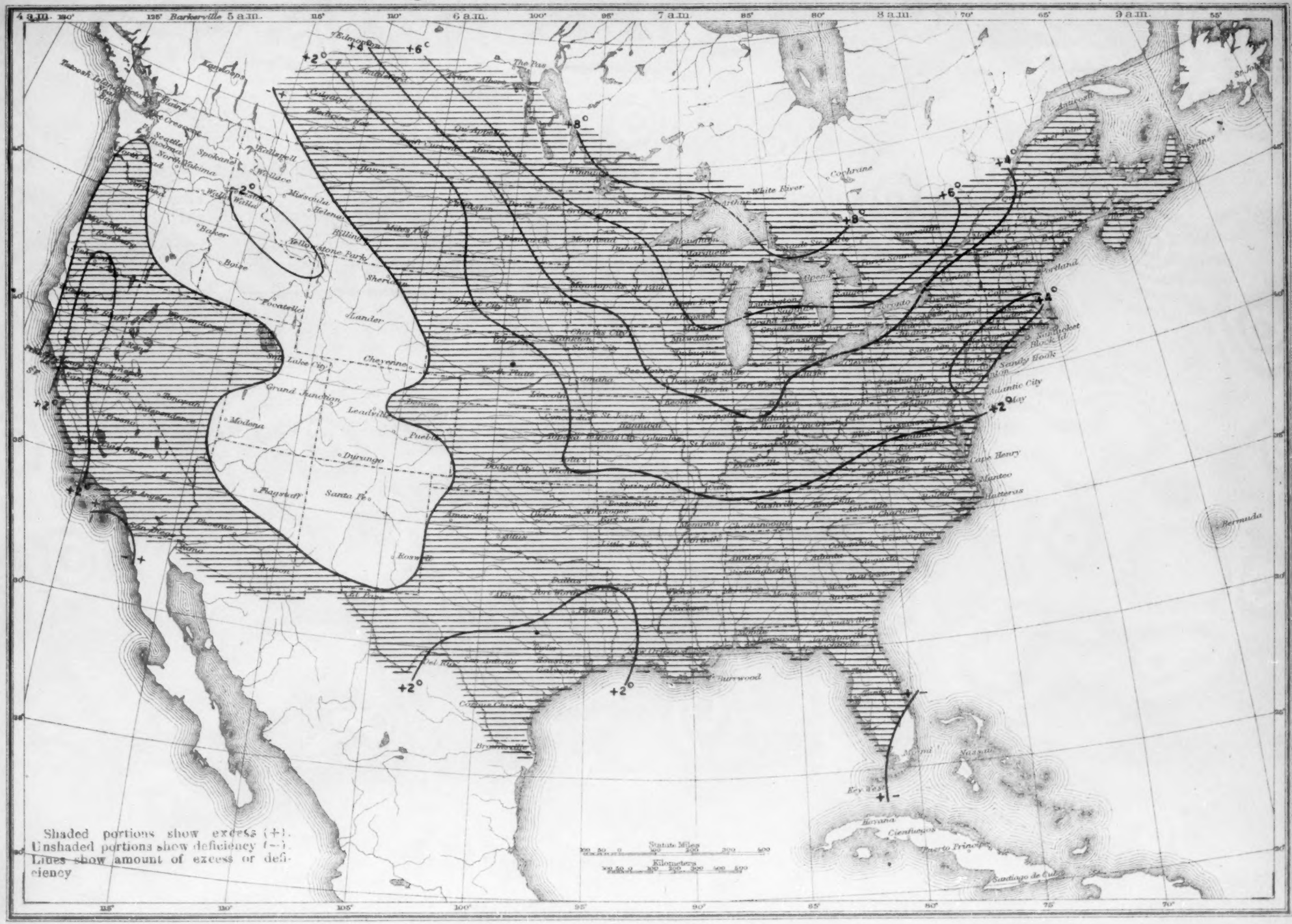

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency
Statute Miles
Kilometers

Chart IV. Total Precipitation, Inches, May, 1922. (Inset) Departure of Precipitation from Normal.

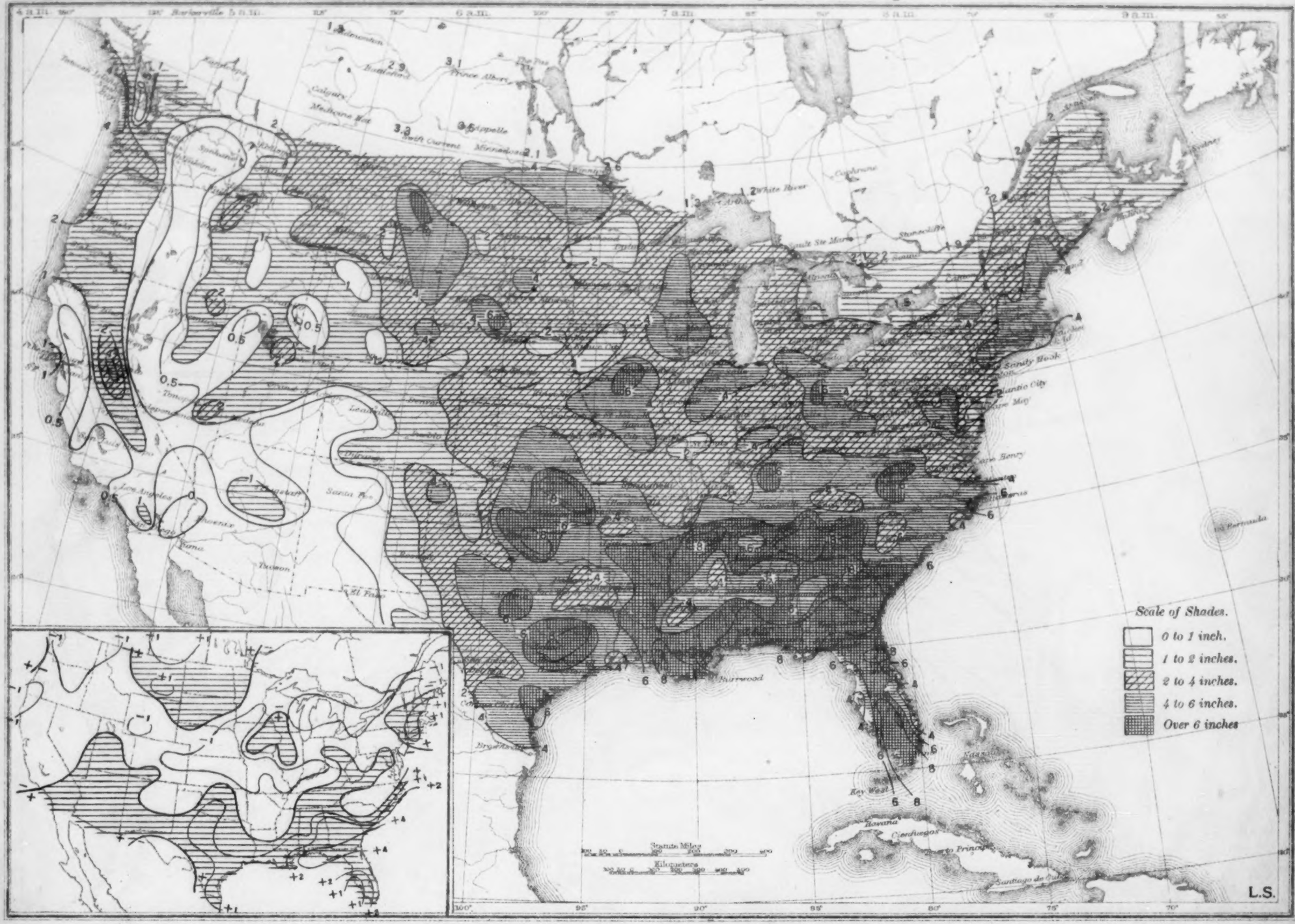


Chart V. Percentage of Clear Sky between Sunrise and Sunset, May, 1922.

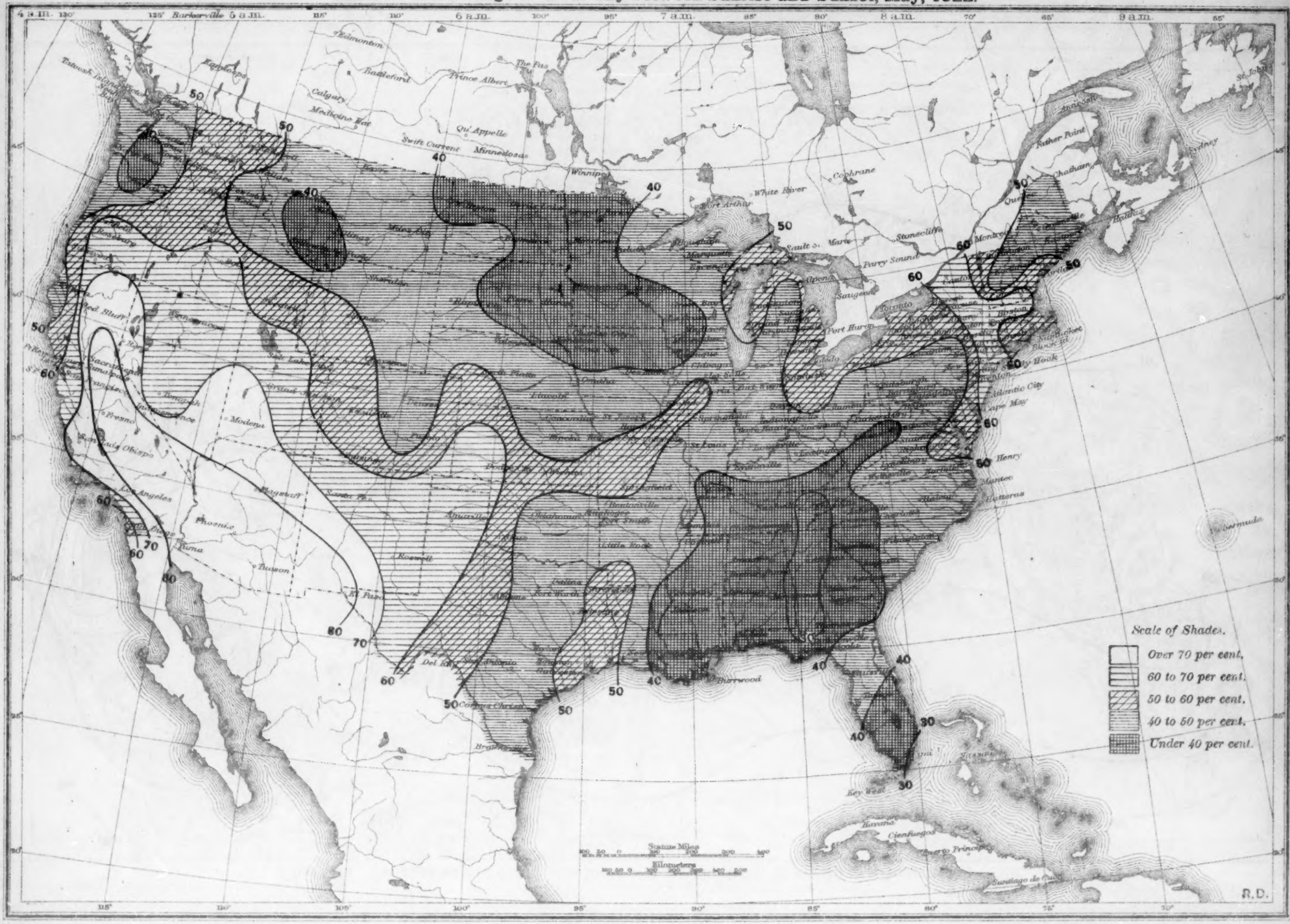
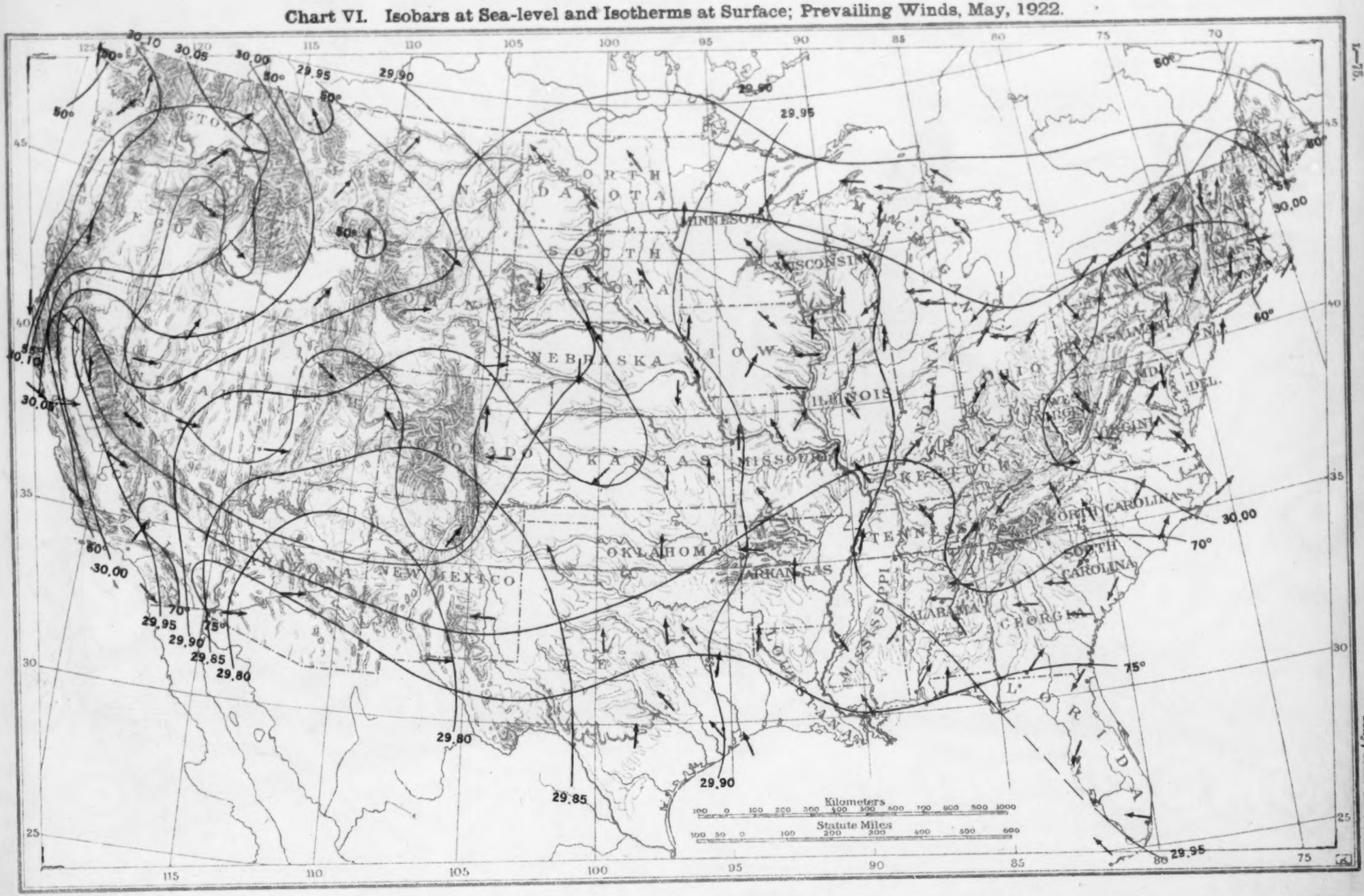


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, May, 1922.



May, 1922. M. W. R.

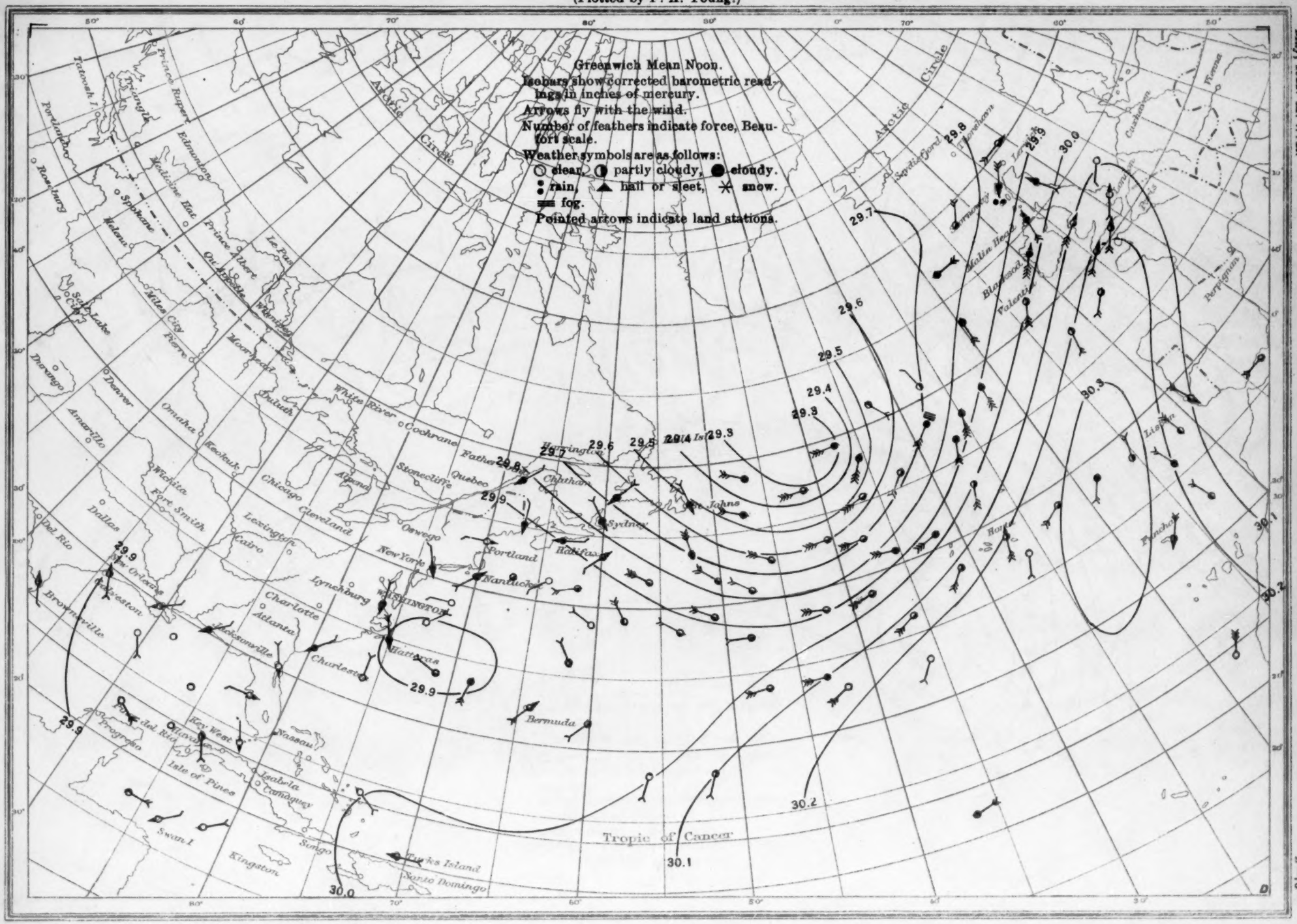
75.

Chart VIII. Weather Map of North Atlantic Ocean, May 15, 1922.

(Plotted by E. A. Young.)

Chart VIII. Weather Map of North Atlantic Ocean, May 15, 1922.

(Plotted by F. A. Young.)



May, 1922. M. W. R.

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Chart IX. Weather Map of North Atlantic Ocean, May 16, 1922.

(Plotted by F. A. Young.)

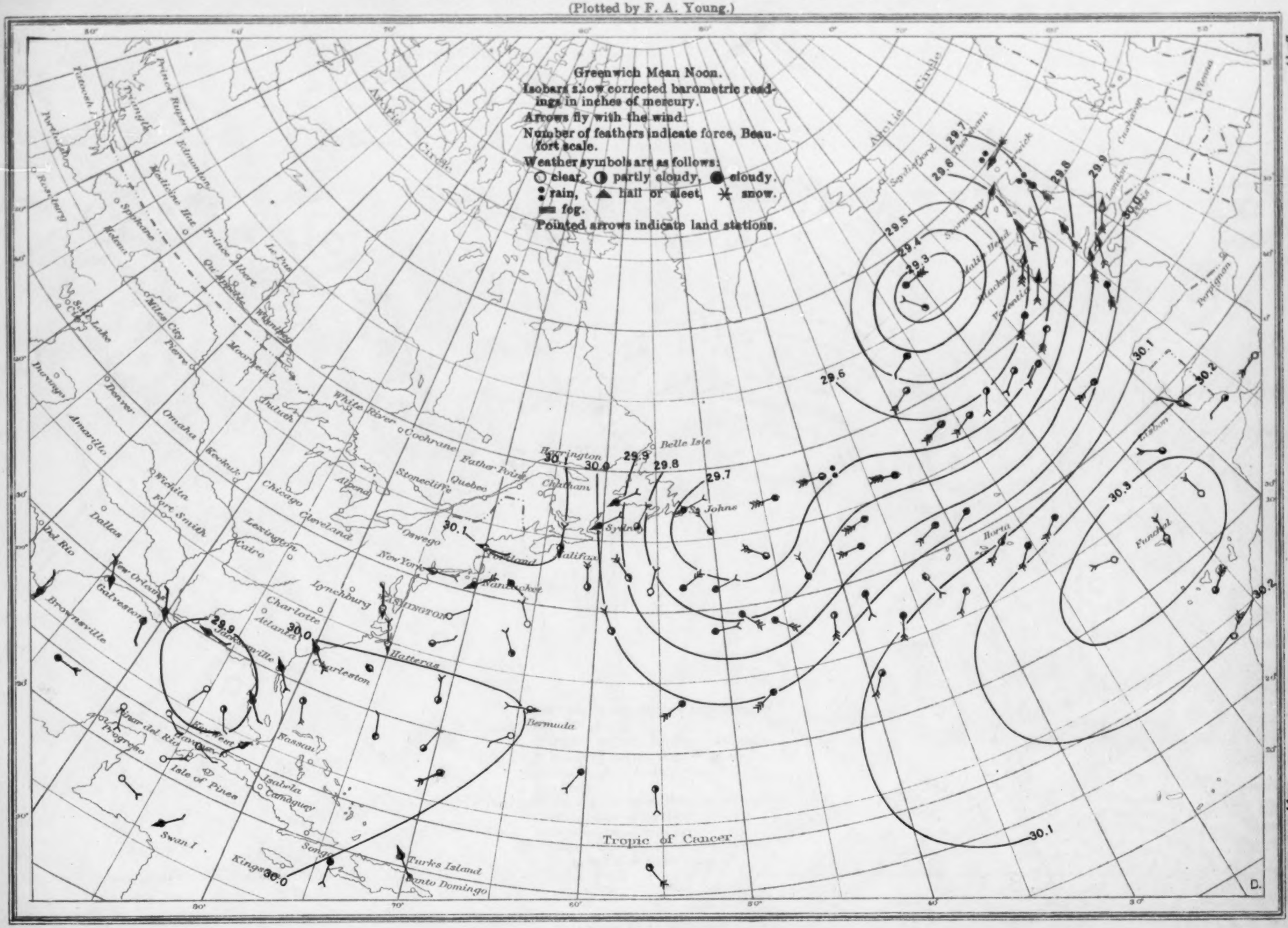
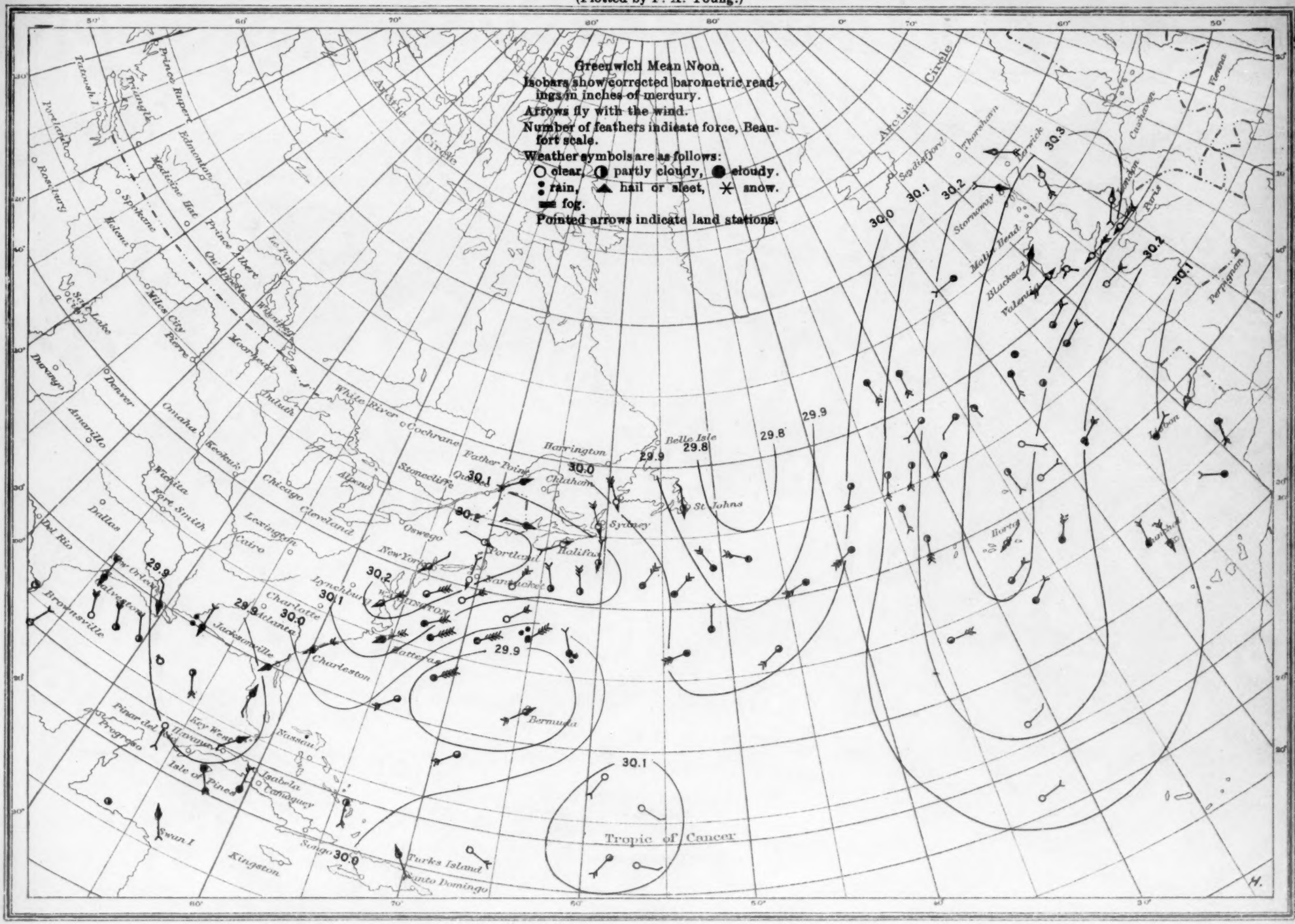

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy.
rain, hail or sleet, snow.
fog.
Pointed arrows indicate land stations.
Tropic of Cancer
D.

Chart X. Weather Map of North Atlantic Ocean, May 28, 1922.

(Plotted by F. A. Young.)

Chart X. Weather Map of North Atlantic Ocean, May 28, 1922.

(Plotted by F. A. Young.)

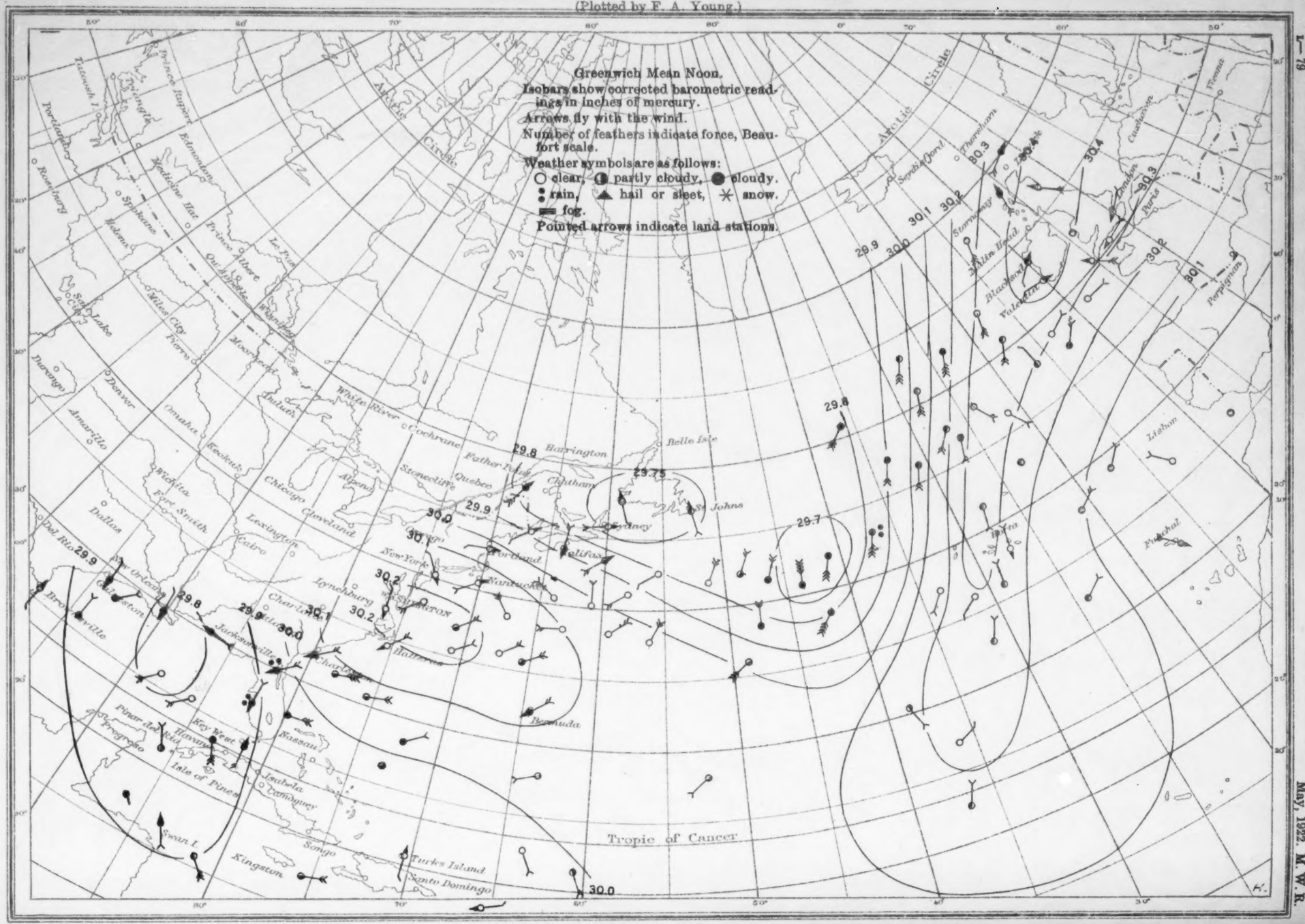


May, 1922. M. W. R.

1—78.

Chart XI. Weather Map of North Atlantic Ocean, May 29, 1922.

(Plotted by F. A. Young.)



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